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"A Most Fantastic Voyage"

THE STORY OF APOLLO 8's RENDEZVOUS WITH THE MOON

By LT. GEN. SAM C. PHILLIPS, USAF
Apollo Program Director, NASA

ABRUPTLY the flight displays on our consoles at Mission Control stopped changing. The curves and lines and scales that told of spacecraft temperatures and pressures, of fuel supplies, of the flight crew's heartbeats, no longer registered new information.

"Loss of signal," announced the flight director matter-of-factly. The clock high on the wall said 68 hours, 58 minutes, 6 seconds had elapsed since the flight began.

Apollo 8, its speed rapidly mounting, had vanished beyond the moon's western rim. On the far side of the moon, the three astronauts expected to fire their engine, slow down the spacecraft, and go into lunar orbit. But for more than half an hour, until they reappeared, we could only sweat it out here on earth. Meantime the three men might as well be at the ends of the galaxy—no human power could reach them, no ear could hear their call.

Apollo 8 stands poised, its target in sight, two weeks before its lift-off for the moon. EKTACHROME BY OTIS IMBODEN © N.G.S.

Now was the critical moment when my tensions really peaked. Now was when I felt the closest thing to apprehension in the entire flight. I had no technical reason for this concern: The equipment had been rigorously tested; everything was working right; the men were confident. Nevertheless, rocketry is still a very new science, and space travel is a long way from the relaxed routine of commercial air travel.

Tension—Then a Welcome Message

Consider that our tiny spacecraft had navigated a quarter of a million miles from home; that its passengers were the first men to leave the environs of earth and experience the unfamiliar influence of another celestial body; that both spacecraft and moon were traveling at high speed; and that Apollo had swung directly across the moon's path and was aiming for a point a mere 70 miles above the lunar surface.

Moreover, this was the first time our giant computer had provided calculations for lunar navigation. If, in spite of all our tests, the computations were slightly off, or if the rocket engine were to fire only 30 seconds too long, the spacecraft would crash on the moon's unfriendly face.

Twenty-five minutes passed. We would have seen Apollo 8 by now if it had *not* made its burn. That was reassuring.

The clock showed deadline; 34 minutes had passed. Now they should be in sight. Astronaut Jerry Carr, the CapCom (capsule communicator), began calling:

Apollo 8, Houston. Apollo 8, Houston.

No answer.

It takes time, of course, to lock on antennas and reacquire the signal. So we waited.

Finally, after a full minute, Jim Lovell came on strong.

Go ahead, Houston. Apollo 8.

The men were safe. Our immediate worries were over. But that was a mighty long minute.

This story began for me five years earlier when I joined the Apollo Program of the National Aeronautics and Space Administration. Over the years it has been my responsibility to supervise establishment of a tremendous industrial capability in rockets and spacecraft; to oversee design, construction, and testing of flight and ground equipment, and the training of thousands of technicians; and to see that the millions of parts of Apollo come together at the right time and place. All this has looked forward to the goal of putting men on the moon—a goal we hope to reach this year.

I have watched the astronauts at their training in geology and orbital mechanics and navigation and spacecraft operation and survival techniques. On occasion I have joined them in their simulators and have seen realistic views of the lunar surface as the spacecraft went through their orbital paces.

We have met setbacks—notably the fire that took the lives of Astronauts Grissom, White, and Chaffee—and we have seen resounding successes as all but one of the earlier Apollo flights gave near-flawless performances.

Timing Vital as Lift-off Approaches

All of this came to a climax for me shortly before midnight last December 20 when I took my place in Firing Room 1 in the Launch Control Center at the John F. Kennedy Space Center. The final countdown was in progress for Apollo 8.

The mobile service structure had been pulled away from Launch Pad 39, and the 363-foot Apollo-Saturn V space vehicle glowed incandescently in the crisscrossed shafts of arc lights (pages 598-9).

Perhaps 200 persons had already taken their places in the firing room (pages 600-601). The big room was quiet; a professional team under Launch Operations Director Rocco Petrone was going calmly about its well-rehearsed tasks.

I checked the countdown manual. The loading of oxygen was under way and going well. (The launch vehicle tanks hold almost a million gallons of liquid oxygen, liquid hydrogen, and other propellants.)

I stepped to another console to check with Lee James, Manager of the Saturn V Program. He told me the launch vehicle and the ground support equipment were in fine shape.

The schedule called for waking the astronauts at exactly 2:36 a.m. This precision

(Continued on page 600)

THIS PAGE FOLDS OUT





"IT WAS an awe-inspiring sight, to come around the far side of the moon . . . and then suddenly see the earth rise." Astronaut James A. Lovell, Jr., thus described the spectacular view above a 200-mile-wide swath of the "rocky and holey" lunar landscape. In a black sky the blue planet floats beyond the moon's horizon; the brown shoulder of Africa shows above earth's terminator—the line between daylight and darkness.

As the spacecraft continued to circle the moon, a voice from Houston, 230,000 miles away, quipped, "A beautiful moon out there." Responded mission commander Frank Borman, "We were just saying that there's a beautiful earth out there." The historic flight, during Christmas week of 1968, marked a giant step in man's march toward the stars.

FRANK BORMAN, NASA

Fueling for its epic journey to the moon (right), the Saturn V stands center stage at Cape Kennedy Space Center, bathed in shafts of light. "It filled my eyes," recalls the author. "I could not escape a feeling of awe." Within a 50-mile radius of the launch pad, hundreds of thousands gathered in the balmy, predawn darkness. Crowding beaches and roads, they waited with mounting tension as the clock ticked to lift-off: 7:51 a.m. EST, December 21, 1968.



KODACHROME (ABOVE AND BELOW) BY BILL TAUB, NASA

Col. Frank Borman, USAF, commander of Apollo 8, dons a "fishbowl" space helmet in the suiting room at Cape Kennedy's moonport. He was also command pilot of the 14-day Gemini 7 mission in December 1965—the longest manned space flight to date. Technician wears a face mask to protect the astronaut from germs.



Capt. James A. Lovell, Jr., USN, navigator on Apollo 8, has a handkerchief tucked in a pocket of his pressure suit in the suiting room. Captain Lovell flew in both the Gemini 7 and Gemini 12 missions and holds the world record for most time in space—572 hours and 11 minutes, including the flight of Apollo 8. In 1967 he was named Special Consultant to the President's Council on Physical Fitness and Sports.

NASA; KODACHROME (ABOVE) BY W. E. GARRETT © N.G.S.

Maj. William A. Anders, USAF, systems engineer, did most of the photography on the mission. Apollo 8 was the Hong Kong-born astronaut's first venture into space. In the white room at the end of the corridor between spacecraft and umbilical tower, Anders receives good-luck wishes just before he enters the command module. A remote-control camera made the picture; photographers cannot enter the room.



characterized the rigorous scheduling imperative in so large and complex an operation.

On closed-circuit television screens we watched the three astronauts—Col. Frank Borman, Capt. James A. Lovell, Jr., and Maj. (now Lt. Col.) William A. Anders—arrive at the launch pad in their white spacesuits and ride the elevator 320 feet up to the command module. At T-minus-2-hours-and-17-minutes (5:34 a.m.) the spacecraft hatch was closed.

At intervals, I checked by intercom with George Low, Manager of the Apollo Spacecraft Program, who sat at a console nearby. Through our headsets we listened to the test conductor and crew go through their final detailed checklists—much like the checklists I have used so often as an Air Force pilot.

Everything was GO—weather, range, tracking network, vehicle, crew. In the Control Center our display lights were all green. I would have to make no unhappy decision to "scrub" this all-important mission.

Anticipation mounted steadily until ignition was announced at T-minus-9-seconds. As I watched through binoculars, the Saturn V lifted on billows of orange and white at 7:51, the time we had set weeks before.

Booster's Roar Blots Out Speech

And so, on the morning of Saturday, December 21, 1968, began the history-making mission of Apollo 8—perhaps the greatest of all human adventures thus far. From my notes, and from the detailed transcript of communications between the men in space and those on the ground, we can tie together the highlights of that six-day flight.

"Tower cleared," I hear Paul Donnelly, the Launch Operations Manager, announce 13 seconds after lift-off. The 6.2-million-pound vehicle, burning 15 tons of fuel a second, is now past any danger of collision with the umbilical tower.

At this point, control passes from our Launch Control Center in Florida into the hands of Mission Control Center at Houston, Texas, and there Astronaut Mike Collins (page 634) takes over all communications with the spacecraft as capsule communicator.

The men in the spacecraft are enjoying the smoothest rocket ride anyone has ever had, but the roar of the booster, reflected from the ground, makes hearing difficult for more than half a minute.

00:00:32* First word from Borman: *The clock is running.* He refers to the clock in

*00 hours, 00 minutes; 32 seconds after lift-off. Italics indicate transcript of space-ground communications.



The Author

For nearly five years 48-year-old Lt. Gen. Sam C. Phillips has guided the program dedicated to putting Americans on the moon by 1970. Named Deputy Director of Apollo in January 1964, he became Director nine months later. From 1959 to 1963, he was director of the Minuteman missile program, the heart of our nuclear defense. Arizona-born and a graduate of the University of Wyoming, General Phillips flew two combat tours with the 8th Air Force in World War II. Since 1943 he has flown almost every type of plane in the Air Force, ranging from the P-38 fighter to recent jets.



Closed-circuit television (below) flashes preflight activities to rows of consoles in Launch Control at Kennedy Space Center. As the Saturn V takes on fuel, hundreds of sensors in the rocket transmit data on pressure, temperature, and other vital functions to the engineers and technicians in this room. Big screens above the consoles show close-ups of launch-pad operations and record the time remaining: 3 hours, 43 minutes, 54 seconds. At 3½ hours before lift-off, the count holds while a member of the back-up crew goes into the spacecraft to make certain everything is in order. Even now Borman, Lovell, and Anders are being suited up for the flight.



EKTACHROME (ABOVE) BY A. PATNOSKY AND KODACOLOR (BELOW) BY BILL TAUB, NASA

At the instant of lift-off, shown on the screen at left, Apollo 8 Flight Director Clifford Charlesworth prepares to assume ground control at Houston's Manned Spacecraft Center. From 13 seconds after lift-off until splashdown, Houston supervised the mission.

the spacecraft that starts operating at the moment of lift-off.

Roger, clock, responds the CapCom.

How do you read, Houston?

Loud and clear.

During the next 11 minutes the craft climbs with ever-increasing speed. The crew watch their panel display closely; it presents 24 instruments, 40 event indicators, 71 lights, and 566 switches. Borman keeps his hand on the controls, ready to take action, but the automatic control system smoothly drops the spent first and second stages into the Atlantic, jettisons the escape tower, and fires the powerful hydrogen engine of the third stage S-IVB.

00:11:25 *We have cutoff,* says Borman.

Apollo has reached a speed of 25,562 feet per second, or 17,428 miles an hour, enough to go into a nearly circular orbit a little more than a hundred miles above earth.

Now Jim Lovell unbuckles himself from his center couch and hurries to attend to his navigation duties. He finds himself floating "all over the place" in his weightless environment. He had not experienced this in his two Gemini flights, where the spacecraft offered much less room and he was always strapped down.

He is also troubled by a somewhat queasy feeling in his stomach, similar to seasickness. But when he slows down and takes it easier, the feeling goes away.

Lovell makes his first sightings with his two optical instruments—a scanning telescope and a sextant—fitted in the side of the spacecraft. During the coast to the moon, the angles between certain stars and the horizon of either earth or moon provide a vital check on the spacecraft gyroscope platform to establish where the craft is in space, its speed, and the direction it is traveling.

01:53:00 Cabin pressure has been holding at 5.2 pounds per



"An incomparable experience," Borman called the launch of Apollo 8. Building thrust for blast-off (left), Saturn V is linked to the tower by steel arms. At full ignition (below), arms swing away, and the rocket is free. "From more than three miles away we saw flames shoot out hundreds of feet," reports the photographer, "but we heard no sound. The silence was eerie. Then, 15 seconds after ignition, the earthshaking roar assaulted us." Steadily climbing (right), the mightiest rocket man has ever ridden frightens a duck—a shoveler—into the air.





square inch since launch, just where it should be, and the cabin temperature is fairly cool—62° F. Lovell, who is now wearing the biomedical harness so the doctors in Mission Control can observe his physical condition by telemetry, has been working hard, but his heart rate is no more than 70 beats a minute, and his breathing is 20 to 25 respirations a minute—all very good.

02:01:50 *How does it feel up there?* asks CapCom.

Very good, very good. . . . It looks just about the same way it did three years ago.

Borman is referring, of course, to his Gemini 7 mission with Lovell in December 1965.

Although the craft is now in "parking" orbit around the earth, this is no time of inaction. On the contrary, it is one of the major GO/NO-GO periods of the flight. Following a long set of mission rules, we thoroughly check out everything—launch vehicle, spacecraft, ground stations—to determine if we can go on to the moon. The decision is GO.

02:50:37 With the spacecraft in sight of Hawaii, the third-stage engine fires the longest burn of the mission—more than five minutes. This is the translunar injection burn, TLI, to put the spacecraft on a path around the moon and back to earth. When the 318-second burn ends, the crew is traveling faster than man has ever flown before—35,532 feet per second, or 24,226 miles an hour. Our analysis shows this speed to be within 16 feet per second of what we had planned; we would have been content with 50.

"You're on your way. You're really on your way now," I hear Chris Kraft, Director of Flight Operations, say.

03:20:59 With the trajectory analysis completed, we are ready for separation of the spacecraft from the rocket. Borman turns a T-handle sharply in his first manual control of the flight. This triggers explosive devices that sever the rocket from the spacecraft and fires the reaction control engines briefly to pull the spacecraft away (page 610). The shock is somewhat greater than the crew expected.

But Anders reports: *We have sep* [separation] *and looking good.*

The third stage, however, appears to stay too close for comfort. Borman estimates it is only 500 to 1,000 feet away.

03:55:00 *It looks like I might have to do a couple more small maneuvers to stay away from the front of this S-IVB . . . it sure is staying close. It's spewing out from all sides like a huge water sprinkler.*

The rocket is venting off unused propellants. Lovell says: *I am looking through the scanning telescope now and I see millions of stars.*

These are fuel droplets from the rocket, a regular snowstorm. They are so thick that they seriously interfere with star sightings.

After much discussion with the ground, a further short burn with the reaction control engines is decided upon.

O.K., as soon as we find the earth, we will do it, says Borman, and the flight controllers erupt in laughter.

This burn increases the distance between spacecraft and rocket to several thousand feet.

04:52:00 *Houston, Apollo 8 with a PRD reading. . . . At 4 hours 4 minutes commander is 0, CMP 04, LMP 02.*

Translated, this means that Bill Anders is reporting on the readings of the personal radiation dosimeters worn by the commander, the command module pilot (Lovell), and the lunar module pilot (Anders), after the crew have

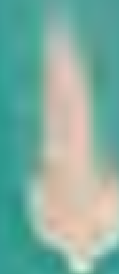
With a startling puff, Apollo 8 creates a cloudlike contrail at 35,000 feet as it bores through the atmosphere. Winds aloft will quickly dissipate the white wake.

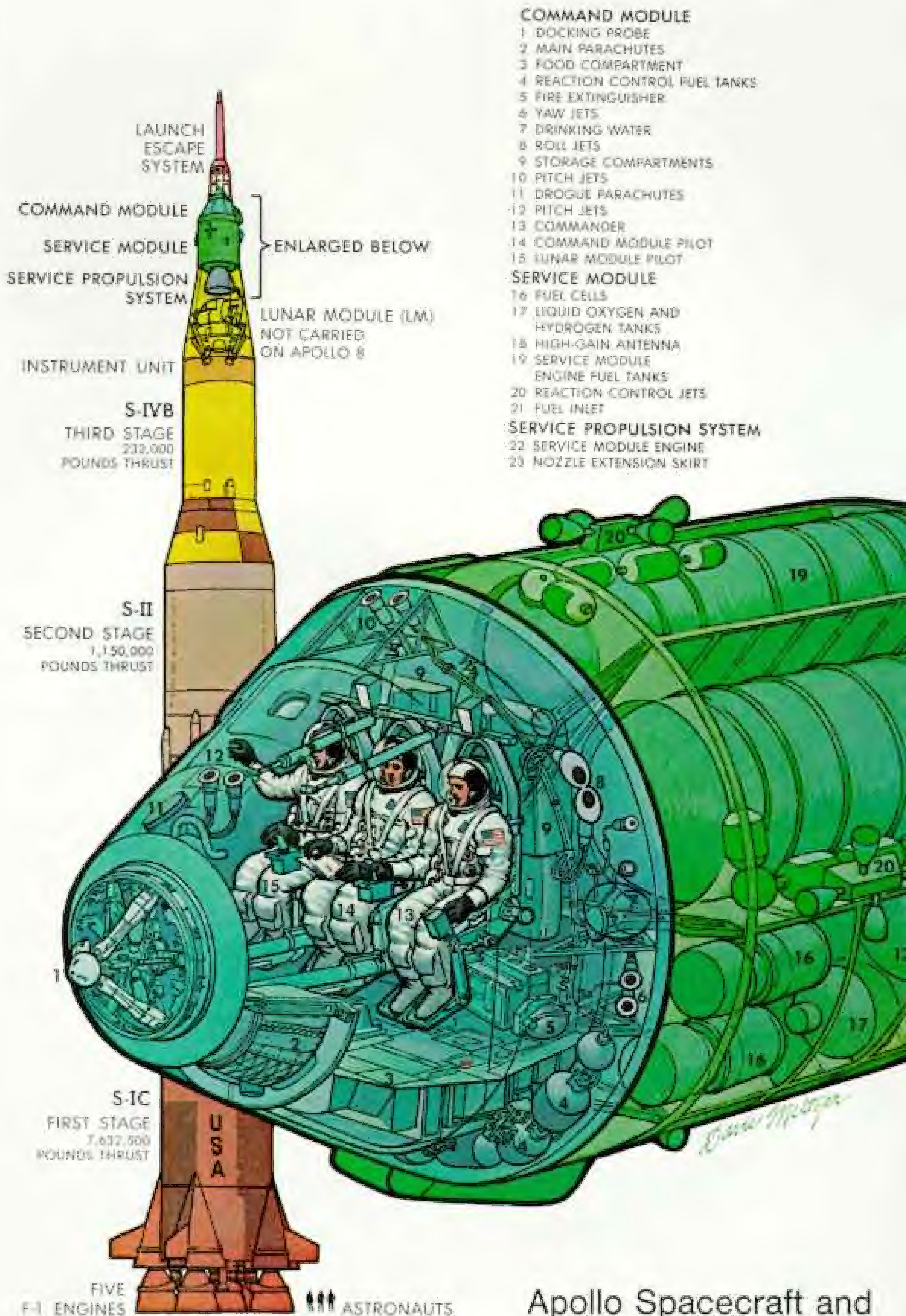
Flames seem to swallow the rocket as Apollo roars heavenward. For a true perspective of its ascent, hold the page above your head.



Watching their "traveling man," as Lovell's older son, James, nicknamed him, the astronaut's family follows Apollo 8's lift-off. Marilyn Lovell, flanked by daughters Susan, left, and Barbara, holds two-year-old Jeffrey.

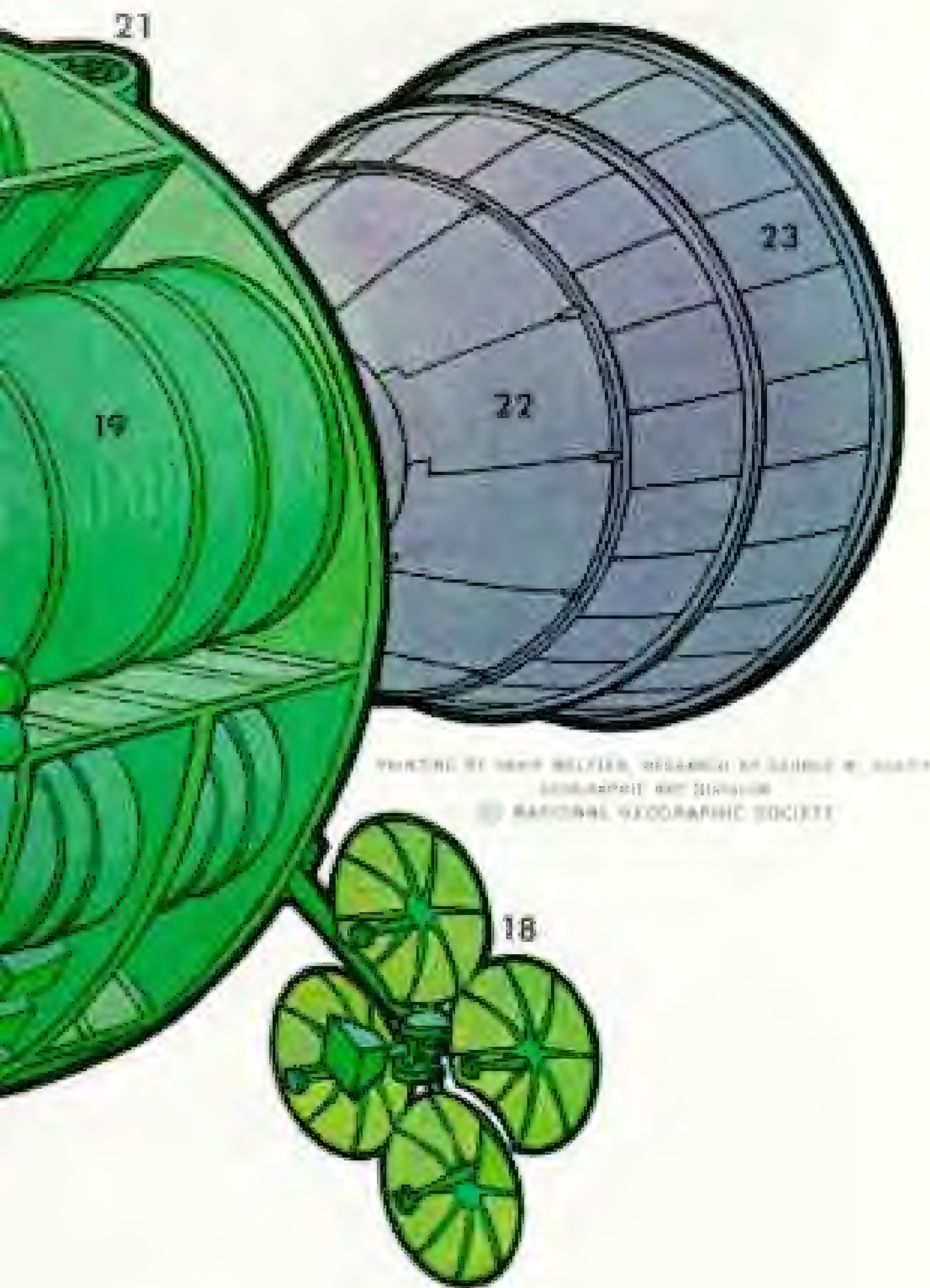






Apollo Spacecraft and

X-ray view of an Apollo spacecraft: In the crew compartment of the command module (blue) the astronauts recline on adjustable couches facing an intricate instrument panel that has been cut away here to show the men. Docking probe on the front of the craft, a part of all succeeding Apollo flights, was not carried on Apollo 8. The service module (green)—life support unit for the command module—carries oxygen-hydrogen fuel cells that provide electrical power for the vehicle and, as a by-product, drinking water for the crew. It also holds propellant tanks. The service propulsion system (purple) houses the vital engine that takes Apollo into and out of lunar orbit and performs all major mid-course corrections. High-gain antenna, jutting below, handles communications, including television signals; it can be turned to point toward earth.



Saturn V Launch Vehicle

passed through the thickest portion of the Van Allen radiation belt. As expected, the readings are negligible. Total radiation on the entire flight turns out to be not much more than that of a chest X-ray.

04:53:00 Lovell gives an enthusiastic account of the view from 21,000 statute miles.

Boy, it's really hard to describe what this earth looks like. I'm looking out my center window, the round window, and the window is bigger than the earth is right now. I can clearly see the terminator [the line separating sunlight from dark]. *I can see most of South America all the way up to Central America, Yucatán, and the peninsula of Florida.*

Anders chimes in: *Tell the people in Tierra del Fuego to put on their raincoats. Looks like a storm is out there.*

Roger, will do, says CapCom.

You might be interested to know the center window is pretty well fogged up.

This is our first hint of a problem that is to plague the crew for the rest of the flight. Three of their five windows become obscured because the sealing compound around them "outgasses" in the vacuum of space and forms a deposit between the triple layers of glass. That problem, we believe, has been solved for future Apollo missions by heat-curing the sealing compound.

05:07:56 Borman: *The S-IVB has started to dump. . . . It's a fantastic sight.*

According to plan, the third-stage rocket—now about three miles away—is ejecting the rest of its oxygen and hydrogen. This action, which fills the sky with great flashes of reflected sunlight for about five minutes (page 611), slows down the rocket. It moves toward the east side of the moon, well out of the way of the spacecraft, which moves toward the west side. The moon's gravity will throw the rocket into solar orbit.

05:33:00 Velocity has been dropping dramatically as the earth's gravitation pulls steadily back on the spacecraft. Now, less than three hours since TLI, and only 25,900 miles out, the spacecraft's velocity is down to about 8,600 miles an hour.

06:20:00 *We have started maneuvering to PTC. Jim is taking off his pressure suit.*

PTC means passive thermal control, or "barbecue mode." The spacecraft turns its long axis facing the sun, then makes a slow once-an-hour roll for even heat exposure.

By this time I have left the Kennedy Space Center on a fast flight to Houston. There I take my place in the Mission Control Center for the rest of the Apollo flight.

09:24:00 Astronaut Ken Mattingly, taking his turn as CapCom, calls Anders: *Sometime when it's convenient for you, I would like to see an oxygen fuel-cell purge.*

The three fuel-cell power plants in the service module are the electric-power generating devices for Apollo. Oxygen and hydrogen react in these cells to provide electricity, drinkable water, and heat. A porous metal plate through which the oxygen and hydrogen pass might get clogged and must be flushed out about every 10 hours.

10:55:00 *All your systems are GO,* CapCom tells the crew. Some 60,000 miles out, the spacecraft is due for a midcourse correction, the first of the flight. It will be a major burn using the service propulsion system, SPS, which has not been tried on this flight. This engine, though it has proved extremely reliable in all tests, is critical: It is the spacecraft's only significant means of propulsion. It must not only put the craft into lunar orbit, but it must later take it out again and send it back to earth.

11:00:00 The engine fires for 2.4 seconds, adding about 25 feet per second, or 17 miles an hour, to Apollo's velocity. In Mission Control we are pleased as we observe on the console displays that pressure and temperatures are normal, indicating that the engine is working fine.

11:30:00 CapCom: *O.K., number one on the list of things is that the flight plan shows commander should hit the sack.*

So Borman turns in for some much-needed rest. But he has trouble going to sleep and asks permission to take a sleeping pill. We did not know it then, but that action was to have potentially serious consequences.

12:00:00 Lovell and Anders continue with housekeeping chores. They report that they are ready to make a periodic dump of the tank holding waste water from the fuel cells. There's a bit of the easygoing banter that often intersperses the technical conversation.

You're looking pretty small down there now, Houston.

We're carrying a big stick, though. . . .

O.K., we're dumping now, Houston. . . . We finally got some stars to see.

Lovell has experienced difficulty finding real stars because of light scattering in his telescope, but now he sees a blizzard of ice crystals.

13:26:00 Borman is still having some trouble going to sleep.

Houston, this is Apollo 8. We're going to try to keep the conversation down here for a



Already farther out in space than man has ever flown, Apollo 8's crew at 3,500 miles gaze down on the shallow Bahama Banks,



WILLIAM A. ANDERS, NASA

turquoise against the darker, deeper Atlantic. Few clouds veil the southeastern coast of the United States and the West Indies, but to the northeast a huge storm system swirls over the ocean. The spacecraft has now kicked out of earth orbit toward the moon.

while so the commander can go to sleep....

During this lull the flight controllers comment to each other on the excellence of the communications, even though Apollo is 78,000 miles away. The messages are coming in to us via the big 85-foot dish at the Honeysuckle Creek station, a third of the way around the world, near Canberra, Australia.

22:50:00 Lovell and Anders are now trying to sleep after being awake roughly 24 hours and traveling nearly 100,000 miles from home. Several hours have passed without much happening. Suddenly Borman breaks silence:

Houston, Apollo 8.

Apollo 8, Houston. Go ahead.

We just broke lock [lost radio contact] *for a minute and I wondered why.*

Roger. Your break-lock is due to the fact we switched antennas over from Honeysuckle to Madrid.

Rotation of the earth requires this switching; a third station, at Goldstone, California, takes over when the others are out of reach.

23:50:00 *Apollo 8, Houston. Over.*

Go ahead Houston. Apollo 8.

Roger, it is time to do a cryo fan cycle, Frank, on all four fans, a short burst from each of them as you did before.

Understand, two minutes each.

Mike Collins's cryptic instructions have to do with maintaining sufficient pressure in the cryogenics—the tanks of super-cold liquid oxygen and hydrogen for the fuel cells. On Apollo 7, Wally Schirra's flight last October, automatic pressure switches were supposed to turn on fans and heaters to keep the temperature of the cryogenics at the proper level. But a fault in the automatic switches temporarily knocked out part of that spacecraft's alternating current power supply.

This could be extremely serious in a moon flight, so we have bypassed the automatic controls in Apollo 8; the astronauts are flipping the switches when necessary.

25:00:00 Anders gets a call from Collins.

I've got a newspaper to read up to you if you give a ring.

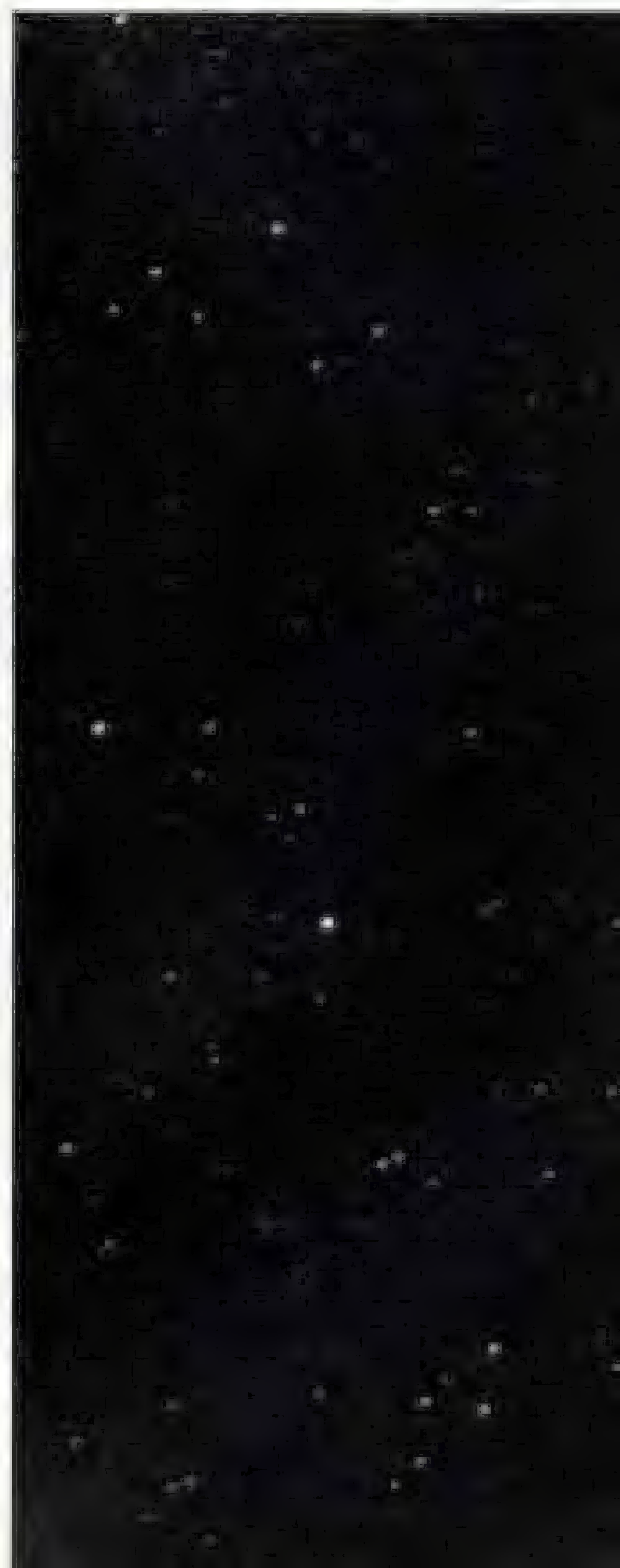
We're ready.

O.K. ... the "Interstellar Times" latest edition says the flight to the moon is occupying prime space on both paper and television. Headline of the [Houston] Post *says, "Moon,*

Jettisoned by Apollo 8, Saturn's third-stage rocket—the S-IVB—floats free. Surrounding it, sunlit particles create the "firefly" phenomenon that John Glenn saw during America's first orbital flight.

Extraordinary photograph made by a tracking camera in Spain shows the 600-mile-

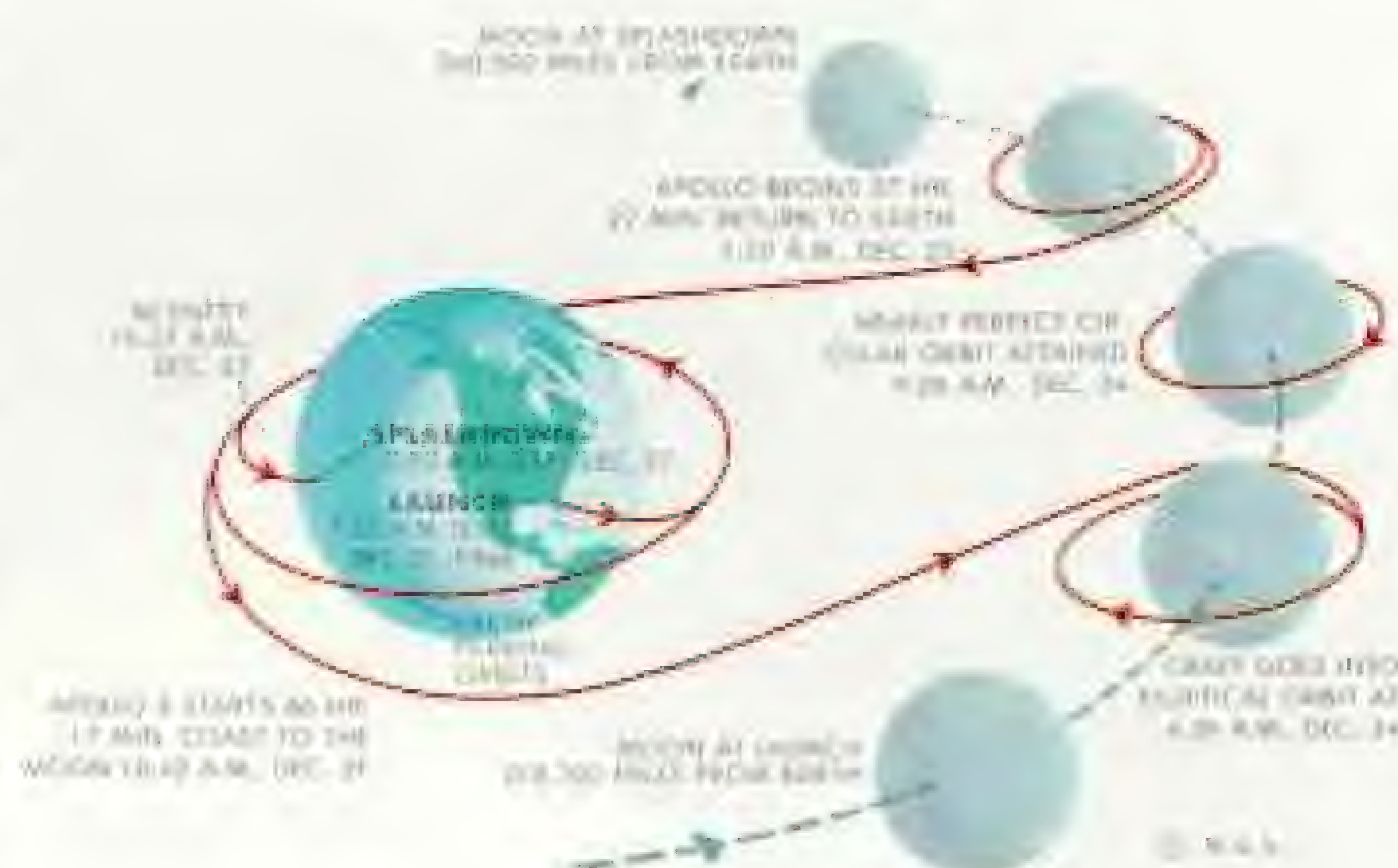




Here They Come!" We understand that Bill Anders will be in private communication today with an old man who wears a red suit and lives at the North Pole....

Roger, we saw him earlier this morning and he was heading your way.

On the spacecraft we have provided a tape machine that records telemetry from Apollo when it is out of communication with ground stations. The recorder also serves as a substitute for a ship's log, since the crew often would not have time to make written entries. At intervals Mission Control commands this recorder to play back its messages to the ground. On such a tape "dump"—customarily used for nonurgent matters—we have learned that about 10 hours ago Borman was sick with nausea, vomiting, and diarrhea. A crew with such symptoms could be in real trouble.



PROFILE OF A PERFECT MISSION

28:00:00 *Apollo 8, this is Houston.... We are on private loop and would like amplifying details on your medical problems.*

Mike, this is Frank. I'm feeling a lot better now. I think I had a case of the 24-hour flu. (Later he decides the cause of his discomfort was really the effect of the sleeping pill.)

wide cloud created by the rocket when it dumped unused liquid oxygen. Now, half an hour later at a height of 26,000 miles, the S-IVB spews a smaller double cloud as it vents excess liquid hydrogen. The speck above and to right of the rocket is the spacecraft.

WILLIAM A. ANDERS, NASA (LEFT); THE SMITHSONIAN ASTROPHYSICAL OBSERVATORY, SAN FERNANDO, SPAIN



Dr. Charles Berry, Apollo flight surgeon, takes the unusual step of talking directly to Borman instead of going through CapCom.

Frank, this is Chuck. The story we got from the tape and from Jim a while ago went like this: At some 10 to 11 hours ago, you had a loose BM, you vomited twice, you had a headache, you've had some chills, and they thought you had a fever. Is that affirm?

Everything is true, but I don't have a fever now. I slept for a couple hours and the nausea is gone. . . . I think everything is in good shape right now.

And as we understand it, Frank, neither Bill nor Jim have anything at the present time except some nausea. Is that right?

No, none of us are nauseated now. We are all fine now.

Dr. Berry prescribes medical treatment for future trouble, and we go into conference at Mission Control.

Since Borman and his crew were in excellent physical and mental condition before launch, and since they are now apparently recovered from any symptoms, Dr. Berry recommends that the flight continue. It would take perhaps 34 hours to bring them home in any case. We're not worried about the Hong Kong flu because the astronauts, as well as the other key people in the Apollo Program, have been immunized.

But it would have been a much tougher problem had we known about Borman's illness at the time he was suffering. This is the closest I come to having to make a major decision on the flight of Apollo 8. Everything else runs so smoothly, thanks to lessons we learned and corrections we made after earlier flights, that no such decisions prove necessary.

31:15:00 About halfway to the moon, the Apollo crew makes its first TV presentation. Using a TV camera weighing only 4.5 pounds, they try to photograph earth, but the light seems too bright. The camera catches Lovell injecting water into a bag of freeze-dried chocolate pudding for dessert, and Anders demonstrating how a toothbrush floats in zero gravity (opposite).

Borman says: *I certainly wish that we could show you the earth. It is a beautiful, beautiful view with predominantly blue background and just huge covers of white clouds—particularly one very strong vortex up near the terminator. We are all in very good shape. . . . It was a very exciting ride on that big Saturn, but it worked perfectly.*

And so the hours flash by, filled with housekeeping duties, star sightings, shifting antennas as the spacecraft turns, updating the computer with new trajectory information, and catching snatches of sleep. The men report that they have not been drinking as much water as the flight surgeons would like, they are not eating as much as planned, and they are far behind on sleep. They inquire at intervals about their families.

Got it! In the weightlessness of space, Astronaut Anders demonstrates how elusive a toothbrush can be. The TV picture was taken during the first live transmission from the moonship, 139,000 miles from earth.



"A Merry Christmas, and God bless all of you. . . ." From 230,000 miles in space come the words of Apollo astronauts to millions of TV viewers throughout the world on Christmas Eve. Here three youngsters in Virginia marvel at photographs from lunar orbit and hear the spacemen read the first ten verses of the Bible: "In the beginning God created the heaven and the earth. . . ."

NASA (LEFT); EKTACHROME BY BRUCE DALE © N.G.S.



To see the earth as it truly is, small and blue and beautiful in that eternal silence where it floats, is to see ourselves as riders on the earth together, brothers on that bright loveliness in the eternal cold—brothers who know now they are truly brothers.—ARCHIBALD MacLEISH



FRANK BORMAN (ABOVE) AND WILLIAM A. ANDERS, NASA





Goodbye, good earth

"WHEN you see the earth slowly recede from you, there is a sensation in the stomach that is hard to describe." That was Lovell's feeling as he looked back and saw the blue-and-white marble called earth hanging in a limitless night. Anders (upper left) prepares to photograph it.

At 20,000 miles (opposite) nearly all the Western Hemisphere lies revealed—from the St. Lawrence River to Cape Horn. Another portrait shows a bright spot of sun reflected from the Pacific (left). Australia appears in the view above.

When they ask about news on earth, CapCom tells them, *You are the news!*

55:09:00 Lovell begins narrating the second TV presentation, from about 200,000 miles out: *We are maneuvering now for the TV. Bill has got it set up in Frank's left rendezvous window, and I'm over in Bill's spot looking out the right rendezvous window. The earth is now passing through my window. It's about as big as the end of my thumb. Waters are all sort of a royal blue; clouds, of course, are bright white. The reflection off the earth is much greater than the moon. The land areas are generally sort of dark brownish to light brown. What I keep imagining is, if I were a traveler from another planet, what would I think about the earth at this altitude? Whether I think it would be inhabited.*

CapCom: *Don't see anybody waving, is that what you are saying?*

Lovell: *I was just kind of curious if I would land on the blue or the brown part.*

Borman: *You better hope we land on the blue part.*

55:38:40 At about 38,900 miles from its goal, the spacecraft has passed into the moon's sphere of influence—that is, the moon now exerts a stronger pull than the earth, and Apollo begins accelerating again. Its speed in relation to earth has dropped to only 3,261 feet per second, or 2,223 miles an hour.

Capsule communicator Jerry Carr notifies the crew in a jocular exchange:

By the way, welcome to the moon's sphere.

The moon's fair?

The moon's sphere—you're in the influence.

That's better than being under the influence, hey Jerry?

60:59:56 So accurate has been Apollo's trajectory that we have canceled two of the planned midcourse corrections. However, ejecting waste water has added slight impulse to the spacecraft and increased its velocity. We now compensate by one final midcourse correction before reaching the moon, 24,000 miles away. A retrograde 11.8-second burn of four of our reaction jets slows down the craft by about 1.4 feet per second. The effect is to lower the spacecraft's pericynthion, or closest approach to the moon, from about 80 miles to about 70.

Now our attentions turn to preparations for LOI, the lunar orbit insertion burn. We make repeated



"Vast, lonely, forbidding," Borman describes the moon. "Very, very stark," adds Lovell. Apollo 8 surveys the Sea of Tranquillity, a likely landing place for future voyagers. Craters in the Taruntius group pock the surface at lower right. The crater Cauchy lies between the two dark lines running almost parallel from right to left—the Cauchy Fault, upper, and the Cauchy scarp. Of the moon's color Anders reports: "All you really need is black-and-white [film]."



WILLIAM A. ANDERS, NASA





"Walls of Langrenus crater are terraced," Lovell pointed out, "with about six or seven different terraces on the way down." Apollo crewmen photographed the 85-mile-wide depression on Christmas Eve as they soared over the moon's near side at an altitude of 175 miles. Small but almost perfectly circular crater at lower right is Langrenus C.

"A dark, unappetizing-looking place," reports Borman. Here the astronauts' camera looks down on unnamed craters on

"One of the amazing features of the surface is the roundness of most of the craters . . . instead of sharp, jagged rocks," Borman radios from lunar orbit. This near-vertical photograph of the far side focuses on a 20-mile-wide section of the floor of an unnamed 100-mile-wide crater with a smaller crater inside it, and a



WILLIAM A. ANDERS, NASA

the far side. Apollo 8 crewmen personally assisted GEOGRAPHIC editors in making color corrections on these photographs to conform with their observations.

still smaller one inside that. Anders likened the lunar far side to "a sand pile my kids have been playing in."



checks on navigation, computer, and spacecraft systems.

62:34:00 Finally capsule communicator Ken Mattingly says: *Everything looks GO right now.*

O.K., Ken, thank you. We just completed Day 3, meal C and now are each going to take a rest period.

O.K., real fine. Wanted to ask if you wouldn't try to get some sack time before we go in. It's going to be a big day.

68:12:00 Borman startles us with an announcement: *As a matter of interest, we have yet to see the moon.*

What else are you seeing? asks CapCom.

Nothing, says Anders. *It's like being on the inside of a submarine.*

In truth, over the long three-day trip, only Lovell has caught sight of the moon, and then only through his telescope. Actually, a small crescent is visible, but the spacecraft has been in the barbecue mode much of the time with the windows turned away from the moon. Besides, all but two small windows are fogged up.

It is early in the morning on the day before Christmas. Now our clock in Mission Control is counting down the time until loss of signal, LOS, when Apollo slips behind the moon. Drawn ever more strongly by the moon's gravity, the spacecraft is accelerating rapidly. With 17 minutes, 51 seconds to go, the big charts at the front of the room show speed of 6,467 feet per second, and the moon only 1,300 miles away.

Ten minutes, 29 seconds: 6,836 feet per second, 950 miles away. No word from the crew; they are too busy.

Five minutes, 30 seconds: only 670 miles to go. Apollo hurtles toward the moon at nearly 5,000 miles an hour. Anxious faces throughout Mission Control watch the clock.

68:57:06 Jerry Carr calls: *One minute to LOS. All systems GO. Safe journey, guys.*

Anders replies: *Thanks a lot, troops. We'll see you on the other side.*

In Mission Control, we can do nothing but wait. During simulations in recent weeks, this has been a good time for coffee breaks. But not today.

Aboard the spacecraft, now out of touch with earth, the crew closely watches the DSKY, the display and keyboard of their computer. Information from the spacecraft's computer, frequently updated with information from the ground, shows on this display. In the final 30 seconds before lunar orbit insertion, a countdown flashes on its face. At T-minus-five-seconds comes a final GO/NO-GO; the computer, in effect, asks the crew, "May I proceed?" To execute the burn, Lovell punches the "proceed" key.

69:08:20 With the spacecraft pointing backward, the service propulsion engine fires beautifully for 246.9 seconds, reducing Apollo's velocity to 3,721 miles an hour. The spacecraft goes into an elliptical orbit around the moon, only 70 statute miles at its lowest point, pericynthion, and about 190 miles at the high point, apocynthion. Without this burn it would have swept on around the moon and headed for home. Our clock shows almost 35 minutes have elapsed since loss of signal.

69:32:44 Suddenly telemetry is re-established. We've made it! Tank pressures and engine data look good. And

Jim Lovell's welcome words ring through the room:

Go ahead, Houston. Apollo 8.

There is an exchange of information about the burn and about the performance of the water evaporators that help keep the spacecraft cool. Then CapCom asks:

What does the ole moon look like?

O.K., Houston, Lovell replies. *The moon is essentially gray, no color. Looks like plaster of Paris. Sort of grayish sand. . . . Coming up now are the old friends Messier and Pickering* [craters] *that I looked at so much on earth.* And I can see the rays coming out of Pickering. They look quite faint, like changes in the color of the mare.*

And then a practical note from the ground:

Bill, if you can tear yourself away from that window, we'd like you to turn off the secondary evaporator.

Lovell continues: *We're getting quite a bit of contrast as we approach the terminator. The view appears to be good, no reflection of the sun back to our eyes.*

He describes seeing a triangular mountain, a landmark that points to one of the proposed Apollo landing sites.

Again, a practical note. Borman calls:

Houston, for your information we lost radio contact at the exact second you predicted. [He refers to loss of signal as they went behind the moon.] *Did you turn off the transmitters at that time?*

Honest Injun, we didn't.

This jesting conversation really holds a deeper significance. The exact timing of loss of signal reassures both the crew and those of us on the ground that the trajectory was correct.

While these other guys are looking at the moon, Borman continues, *I want to make sure we have a good SPS.*

He wants a report from our instrument

*See "That Orbèd Maiden . . . the Moon," by Kenneth F. Weaver, and the wall-map supplement, **The Earth's Moon**, in the February 1969 NATIONAL GEOGRAPHIC.



"We can see quite a bit of detail," Lovell reported as Apollo 8 orbited the near side. This photograph, taken with a telephoto lens, shows the 40-mile-wide crater Goclenius crossed by a prominent rille that cuts the outer wall. Above, left, are craters of the Colombo and Magelhaens groups. Back on earth, James Lovell summed up: "I stepped out of the house a few days later and looked up at the moon, and I could scarcely believe that I was there." WILLIAM A. ANDERS, NASA



readings on the all-important service propulsion system engine that will get them back home.

They have now passed the terminator and are looking at the part of the moon lit only by reflected light from earth. *Earthshine is about as expected, Houston. Not as much detail, of course, as in sunlight, but you can see the light craters quite distinctly.*

We begin to get indications that the crew, working extremely hard, are tiring. Frank says: *The flight plan looks a lot fuller than it did in Florida.*

70:56:35 Once again we get loss of signal as the craft goes behind the moon.

When Apollo reappears, the earth enjoys its first televised views from lunar orbit.

Borman: *The moon is very bright and not too distinct in this area.*

Anders: *The color of the moon looks like a very whitish gray, like dirty beach sand with lots of footprints in it. Some of these craters look like pickaxes striking concrete creating a lot of fine haze dust.*

Lovell: *As a matter of interest, there's a lot of what appear to be small new craters that have these little white rays radiating from them. . . . There is no trouble picking out features that we learned on the map.*

73:35:07 On its third swing behind the moon, Apollo makes a second burn of 9.6 seconds with the service propulsion engine to put the craft into a nearly circular orbit just about 70 statute miles up.

The next pass on the moon's front side is quiet, with Borman taking over the navigation duties while Lovell rests, and with Anders extremely busy shooting movies





Homeward bound, Lovell takes navigational sights with scanning telescope and sextant. Now the astronauts peer down on an almost full moon. Diagram at right charts its most prominent features.





PAINTING BY WILLIAM H. BOND, GEOGRAPHIC ART DIVISION © N.G.S.

Passengers on a jetliner view Apollo 8's re-entry

"IN MY 26 YEARS of airline flying, this is the most spectacular, sensational thing I've ever watched," says Capt. James Holliday of the scene portrayed above. Skipper of Pan American flight 812 from Fiji to Honolulu on December 27, Captain Holliday was piloting his Boeing 707 across the Pacific at the moment of Apollo 8's re-entry. Suddenly he spotted a tiny pinpoint of light a bit below and left of the star Capella. Immediately he announced the sighting over the public address system, and passengers and crew could see the spaceship over the left wing tip.

"We watched as the color of the capsule brightened to pinkish red," said Holliday, "and we noticed a tail similar to that of a comet forming directly behind. The tail was short at first, a dull orange streak. As Apollo 8 gradually came closer in the star-filled black sky, its glow changed from soft orange to yellow and, finally, to incandescent white. The orange-red tail grew longer and more vivid. It did not flare; it was perfectly straight and of constant thickness, like a slash made by an artist on a piece of black velvet. We estimated the length of the tail at 125 miles.

"We watched the spacecraft for three minutes. By that time I had turned the plane around a full 180 degrees to follow it. When it neared the splashdown area, the tail grew shorter and the brilliant white light diminished in intensity. Suddenly it went out, as if somebody had snuffed a candle—the Paul Bunyan of all Roman candles. We never saw the three leading characters of this drama. There was no musical score, nor was one needed. But the set was fantastic—and we had the best seats in the house!"



Breaking up as it enters earth's atmosphere, the service module of Apollo 8 becomes a fiery projectile (upper right). An Air Force plane specially equipped with camera pods photographed the fireball.



"We hit with a tremendous impact," Borman says of the Pacific splashdown. The spacecraft turned over, leaving the astronauts dangling upside down until balloons on the tip inflated and righted it. In the eerie light of a flare dropped by a helicopter, a Navy frogman climbs up to the hatch.



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By dawn's pale light, the last maneuver

WHILE APOLLO 8 bobs like a cumbersome cork in the four-foot waves of the Pacific, a recovery helicopter hovers overhead and prepares to lower a "Billy Pugh Net," a pick-up device named for its designer. Awaiting the lift, the astronauts sit in a life raft beside the capsule. The net lifts Borman (opposite above), as Lovell awaits his turn (opposite center).

A little more than an hour before, the spacecraft had hit the water within sight of the carrier U.S.S. *Yorktown*. A Navy frogman had tied on a small sea anchor to keep it from drifting in the wash of helicopter rotors; two others had attached a bulky flotation collar. When the 225-pound hatch of the command module swung open, the astronauts climbed out: Lovell first, Anders (opposite below), and finally Borman.

Scarcely had the spacemen splashed down than congratulatory messages began pouring into the United States from around the world. From Spain wrote the descendant of another explorer to the National Geographic Society: "I send you my most sincere congratulations on the great feat achieved by your astronaut compatriots." It was signed Christopher Columbus.

and still pictures. He is switching from one couch to the other, using several kinds of cameras, lenses, and film.

Cabin pressure holds nicely at just under five pounds per square inch; temperature is up to 77 degrees.

74:38:00 Frank Borman, a lay reader in his Episcopal church in League City, Texas, reads a prayer to be recorded on the ground:

This is to the people at St. Christopher's, actually to people everywhere:

Give us, O God, the vision which can see Thy love in the world in spite of human failure. Give us the faith, the trust, the goodness in spite of our ignorance and weakness. Give us the knowledge that we may continue to pray with understanding hearts, and show us what each one of us can do to set forth the coming of the day of universal peace. Amen.

76:40:00 *Apollo 8, this is Houston.*

I say, how about a little bit of that news you promised?

Roger. We got the "Interstellar Times" here. Your TV program was a big success. It was



KODACHROME (ABOVE AND BELOW) BY LT. (JG) DICK FLANAGAN, NASA





U.S. UNDERWATER DEMOLITION TEAM NO. 12, NASA

viewed this morning by most of the nations of your neighboring planet, the earth. It was carried live all over Europe, including even Moscow and East Berlin. Also in Japan and all of North and Central America, and parts of South America.

I am frankly surprised at the worldwide reaction. The success of the mission, of course, means a great deal to everyone in Apollo—it is a tremendous step that puts us within reach of our lunar landing goal. But I have not really anticipated the flood of international applause, now beginning to come in, that ranks Apollo 8 with history's most significant explorations.

80:15:00 Anders: *The back side looks like a sand pile my kids have been playing in for a long time. It's all beat up, no definition. Just a lot of bumps and holes. The area we're over right now gives some hint of possible volcanic action.*

Lovell: *I had occasion to watch the sun come up, and at about two minutes before sunrise the limb* [edge] *begins to brighten up into sort of a fine white haze, a faint glow.*

It is the voice of an obviously very tired Jim Lovell. His flight plan has kept him extremely busy. Anders, too, has been so busy that he has sandwiched eating periods between photographing landmarks.

Borman is concerned about his crew. In a few hours they must be in good shape for the transearth injection, or TEI burn; this vital maneuver must succeed or Apollo and its crew will stay in orbit about the moon.

82:24:00 CapCom calls Borman:

Some time back we noted evidence of a restart in the computer and wondered if you had any remarks about it.

I know it. Jim got screwed up on one of these programs. He got kind of tired here and we got a restart and a couple of program alarms. I don't know what he did.

What had happened was that Lovell punched the wrong number in the DSKY, or computer keyboard, causing the computer to erase part of its memory and start over. This development now causes us substantial worry for fear the part of the memory that controls re-entry might have been lost too. We must spend many hours in exhaustive checks to assure that this has not happened.

Meantime, Borman assumes the prerogatives of skipper and takes action. *I'm going to scrub all the other experiments. We are a little bit tired. I want to use that last bit to really make sure we're right for TEI.*

Roger, I understand, Frank.

And five minutes later Borman reports:

Lovell is snoring already.

Yeah, we can hear him down here.

This problem of crew fatigue has led us to change plans for future lunar missions: we will allow the men to rest much of the time in translunar passage, and we will change the sleep-wake cycle so that all three men can sleep at once. At least one of them will have on his headset so we can call if trouble shows up on our ground displays.

Also, we have already limited the work



The first circumnavigators of the moon grin as they come aboard the *Yorktown.* Anders and Lovell wear beards after six days in space; Borman used an electric razor in the helicopter. Millions of television viewers watch the welcoming reception, rejoicing in the voyagers' safe return. After thanking the carrier's crew and all others who



made their flight possible, the astronauts go below, there to hear congratulations from the White House and to talk with their families in Houston.

the first astronauts will do on the lunar surface.

85:43:00 On the ninth and next-to-last revolution, the crew provide another TV presentation with graphic descriptions.

Borman: *The moon is a different thing to each one of us. . . . My own impression is that it's a vast, lonely, forbidding type of existence, a great expanse of nothing, that looks rather like clouds and clouds of pumice stone. It certainly would not appear to be a very inviting place to live or work.*

Lovell: *Frank, my thoughts are very similar. The vast loneliness of the moon up here is awe-inspiring, and it makes you realize just what you have back there on earth. The earth from here is a grand oasis to the big vastness of space.*

Anders: *I think the thing that has impressed me most is the lunar sunrises and sunsets. . . . The long shadows really bring out the relief.*

Borman: *The sky is pitch black and the moon is quite light. And the contrast between the sky and the moon is a vivid dark line.*

Lovell: *Actually, I think the best way to describe this area is a vastness of black and white, absolutely no color.*

Borman: *The sky up here is also rather forbidding; a foreboding expanse of blackness with no stars visible in daylight.*

The description is grim. Yet these men recognize, more than most people do, that in this forbidding moonscape lie enormous scientific and technical challenges. Man's knowledge will make significant gains from the instruments future astronauts will leave on the moon, and from the lunar samples they will soon bring back.

As the spacecraft approaches the terminator, the crew comment on the sharp contrast between the light and dark areas below. Then Anders introduces what many people remember as the most moving moment of the flight. *For all the people back on earth, the crew of Apollo 8 has a message that we would like to send to you.*

And so these three astronauts, who more than any other men have seen the evidence of creation, pause in their journey to read, in turn, the most appropriate words imaginable for the scene below them—the majestic opening words of the Book of Genesis.

"In the beginning God created the heaven and the earth. And the earth was without form, and void; and darkness was upon the face of the deep. And the spirit of God moved upon the face of the waters. And God said, Let there be light: and there was light. And God saw the light, that it was good: and God divided the light from the darkness. . . . And God saw that it was good."

And from the crew of Apollo 8, we pause with goodnight, good luck, a Merry Christmas, and God bless all of you—all of you on the good earth.

The pace now begins to quicken as we all prepare for the transearth injection. Lovell makes a final star check and straps himself back in his couch. CapCom gives his last message before Apollo is out of reach over the far side of the moon.

Apollo 8, Houston. We have three minutes until LOS. All systems are GO.

And from the spacecraft we get a very terse *Roger. Thank you.*

I had had my own worst tension a few hours earlier. For many others, however, now is the real moment of truth. Failure of this maneuver will mean disaster and loss of three brave men. All over the world people are holding their breath, waiting for the spacecraft to reappear over the lunar horizon.

89:28:47 We have the signal; a cheer goes up among the flight controllers. There is a bit of trouble locking on; then, once again, Lovell's voice brings reassurance:

Please be informed there is a Santa Claus!

Behind the moon, at 89 hours, 19 minutes, and 17 seconds, the faithful engine had fired for 203.7 seconds, placing the spacecraft safely on its trajectory back to earth.

Holiday Dinner in Space: Real Turkey

It is Christmas morning now. Deke Slayton, Director of Flight Crew Operations and himself one of the original seven astronauts, takes the CapCom's microphone: *Good morning; Deke here. I just would like to wish you all a very Merry Christmas on behalf of everyone in the Control Center, and I'm sure everyone around the world. None of us ever expected a better Christmas than this one.*

And Borman responds: *Thank everybody on the ground for us. It's pretty clear we wouldn't be anywhere if we didn't have them doing it or helping us out here.*

The spirit of generous appreciation for the team play that has made Apollo possible is strongly characteristic of the Apollo 8 crew. Repeatedly during the flight, and after, they pay tribute to the flight controllers, the engineers and technicians, the multitudes of workers in the factories who put Apollo together, the far-flung network that tracks and recovers Apollo astronauts, and all the myriad others who carried out their roles so faithfully.

In his gear, Borman is carrying a number of silver lapel pins of Snoopy the Astronaut, designed by cartoonist Charles Schulz, to reward a few who have made especially valuable contributions. Snoopy has become the symbol of excellence in workmanship throughout the Apollo Program. On posters in factories and offices across the nation, Snoopy has encouraged workers with such maxims as this: "It will not be one man going to the moon . . . it will be an entire nation."

For the astronauts, the long, relatively uneventful downhill journey home has begun.

While some of us in Mission Control have cold coffee and baloney sandwiches for Christmas, the crew aloft enjoy their best meal of the trip—real chunks of turkey with honest-to-goodness gravy that can be eaten with a spoon instead of squeezed from a plastic bag.

They catch up on sleep, make pleasant jokes about flying saucers and Santa Claus and the fact that Isaac Newton is driving the spacecraft. At one point Borman sums up the flight as "a most fantastic voyage."

They enjoy news of congratulatory messages pouring in from all over the world, even from Russia and other Communist lands. Everyone seems impressed, in fact, except the few members of London's International Flat Earth Society, who say it is all a hoax.

128:01:00 In their last TV presentation, while still more than 110,000 miles out, Anders remarks: *I think I must have the feeling that the travelers in the old sailing ships used to have, going on a long voyage away from home. And now that we're headed back, I have that feeling of being proud of the trip, but still happy to be going back home. . . . We'll see you back on that good earth very soon.*

The log from now on has little excitement until 30 minutes from the end of the flight. Then things begin to happen fast.

146:28:48 The crew in their command module jettison the service module with its engine and its supplies of fuel and power and oxygen. Now the command module is very vulnerable. And the velocity is increasing dramatically, rising to 24,695 miles an hour.

146:46:13 At 400,000 feet from earth, the men feel the first hint of deceleration as the spacecraft enters the atmosphere.

146:46:37 Radio blackout begins, to last just over five minutes. It is caused by ionization of the atmosphere around the plummeting craft. In the predawn darkness, an eerie orange glow surrounds Apollo.

146:47:23 At about 192,000 feet, the heat shield proves its worth. Its leading edge reaches a temperature of 5,000 degrees, causing "a real fireball." To Borman it is like being inside a neon tube. Now the astronauts briefly



EKTACHROME BY NATIONAL GEOGRAPHIC PHOTOGRAPHER JAMES L. STANFIELD © N.G.S.

"Exploration really is the essence of the human spirit," Colonel Borman told a Joint Meeting of Congress on January 9, 1969, "and to pause, to falter, to turn our back on the quest for knowledge, is to perish." He was hopeful, he said, that "in a few years we will have an international community of exploration and research there [on the moon], much the way we have in the Antarctic." Earlier President Lyndon B. Johnson had presented NASA's Distinguished Service Medal to the astronauts in the White House. The following day New York City honored them with a ticker-tape parade, and Broadway became Apollo Way.

experience 6.8 g's—maximum stress of the flight. The carrier U.S.S. *Yorktown*, main ship of the recovery fleet in the Pacific, makes radar contact with the spacecraft.

146:51:48 Once again we hear from the spacecraft, and once again it is Lovell who brings us welcome news: *We are in real good shape, Houston.*

146:54:48 At 24,000 feet the drogue chutes pop open. Shortly after, the main chutes blossom—a mighty welcome sight to the astronauts in the flashing light of their stroboscopic beacon.

147:00:42 Apollo lands in the Pacific with a tremendous impact, 1,050 miles southwest of Pearl Harbor and less than three miles from the *Yorktown*. It turns upside down, leaving the men dangling in their straps for four and a half minutes. Then large bags on the command module's tip inflate, and the craft flips upright. Seasickness assails one of the crew as the craft bobs in four-foot waves.

147:30:00 Rescue helicopters circle overhead, waiting for daylight. The helicopter skipper radios to ask if the moon is made of Limburger cheese.

"No," Anders replies, "it's made out of American cheese."

With the first light of dawn, December 27, frogmen fasten a flotation collar to the command module so that it cannot sink. The astronauts climb out and are whisked away by helicopter to the *Yorktown*—and to the plaudits of a waiting world (pages 626-9).

As Frank Borman had said, "a most fantastic voyage."

THE END


UNITED
STATES

And Now to Touch the Moon's Forbidding Face

To the Chinese this may be the Year of the Rooster, but to mankind in general it is the Year of the Moon, when ambitious earthmen for the first time will seek to set foot on another heavenly body

By KENNETH F. WEAVER
Assistant Editor

RECENTLY, the National Aeronautics and Space Administration received a letter from a South Carolina schoolboy:

"Dear Sir: I want to go up in space, but I want to do it while I am little and too young to be afraid of the dangers."

I thought of that young man and his letter on a recent visit to the Grumman plant on Long Island where the lunar module—known as the LM—is being fabricated. This space taxi, designed to carry two Apollo astronauts from their spaceship to the lunar surface, is the least streamlined and most fragile, and seems the most unlikely, of all spacecraft yet designed to transport men.

Squat and ungainly, the LM suggests a bug 23 feet high. It has a two-part body, spindly jointed legs, numerous bristling antennas and appendages, two eyelike windows, and an eggshell skin. Fifteen of the strange craft have been ordered by NASA, for tests and for actual landings on the moon.

As I stood in Grumman's super-clean room and watched two of the lunar modules slowly taking shape, I wondered: Can they really fly?

Outer appearances, I found, belie the qualities of this remarkable vehicle. The airless moon does not require a streamlined aerodynamic shape, and great sturdiness is not needed where gravity is only a sixth that of earth's. The astronauts say that the LM is well designed for what it must do. And it is beautifully made; more than a million parts are fitted together with a watchmaker's precision.

The LM crams an unbelievable amount of equipment into its limited space. Not counting 12 tons of propellants, the LM weighs only four tons, about the same as two Ford cars. Yet this includes a complete life support system with water and oxygen for twice the 22 hours of the first lunar visit, two radar systems, four radio systems, two computers, and two major rocket engines—one for lowering LM to the moon and one for taking it back into lunar orbit.

In fact, LM is unique on two counts. It is the only spacecraft capable of landing and taking off again, and it has the only large rocket engine whose thrust can be varied.

Footpad Probes Signal First Contact

This summer, if all has gone well, Astronauts Neil Armstrong and Edwin Aldrin hope to attempt the long-awaited lunar landing, as shown on the opposite page.

On the coast to the moon, the command-and-service module has separated from the third-stage S-IVB (page 606), turned around, and docked nose-to-nose with the LM. Then springs, triggered by explosives, push the LM and the attached spaceship free of the rocket. Now in lunar orbit, about 70 miles up,

In an artist's preview of man's greatest feat of exploration, Apollo's spidery-legged lunar module separates from the command module in orbit 70 miles above the moon. Cutaway painting shows the astronauts in their spacecraft as they come around the eastern rim. Earth floats in the distance, almost a quarter million miles away. The command module pilot adjusts his position by firing two reaction control jets. For the actual landing, the LM crew will first fire their own reaction control jets (black clusters) to achieve proper attitude. Then they will twice fire the black descent engine at the bottom, the first burn lowering them to 50,000 feet, the second slowing their speed for the coast to touchdown. Dishlike and star-shaped appendages at the top of the LM are radar and radio antennas.

PAINTING BY DAVIS MELTZER, GEOGRAPHIC ART DIVISION © N.G.S.



Fisheye lens focuses on Neil A. Armstrong (right) and Edwin E. Aldrin, Jr., in a simulator of the LM during their long, intensive training at the Manned Spacecraft Center. For Armstrong, the commander, and lunar module pilot Aldrin, a successful mission will make them the first Americans to land on the moon.

Michael Collins (below), the command module pilot for the moon-landing flight, would have occupied the center seat of Apollo 8 but for surgery a few months earlier. Instead he served as a capsule communicator.



How moon samples will be examined

AT THE LUNAR RECEIVING LABORATORY in Houston's Manned Spacecraft Center, the 63 pounds of soil and rock that Apollo astronauts hope to collect will undergo intense scrutiny. First, the tightly sealed aluminum boxes containing the samples will be washed with powerful peracetic acid (above) to destroy earthly organisms. A technician demonstrates how he can reach into a protective chamber to hose down the case by inserting his arms into heavy rubber gloves. The box is dried with nitrogen gas and opened in a vacuum chamber; then samples are sent by conveyors to other chambers for testing.

As with this earth rock (below), the precious moon samples will be measured and weighed, checked for radiation and magnetism, tested with spectrometers to learn their chemistry, and X-rayed for mineral make-up. Pulverized lunar material fed to living plants and animals may help biologists discover the effect on living things on earth. The astronauts will be quarantined until 21 days after leaving the moon, while doctors determine whether they have suffered any lunar contamination.



the two men crawl through a tunnel into the LM, separate the craft, and—leaving Michael Collins at the controls of the mother ship—make a one-hour-and-eight-minute descent to the moon.

The descent engine slows their moonward rush to three miles an hour, allowing the two men, standing at their tiny windows, to maneuver to a favorable landing spot. Five-foot-long footpad probes signal first contact with the lunar surface, and the spidery legs absorb the shock of impact. The dangers of space flight are momentarily over.

Afoot on earth's ancient satellite after climbing down a seven-foot ladder, the two explorers face new hazards. But multilayered thermal garments protect against radiation, heat, and micrometeoroids, and a dark visor cuts the sun's glare.

Fatigue now becomes an important threat. The bulky pressure suit is hard



PHOTOGRAPHS BY RALPH MORSE, LIFE

to work in. Moreover, the portable life support system—a sizable backpack—raises a man's center of gravity so high that it takes extra effort just to maintain balance.

For these reasons, activity on the first lunar landing is limited. During a two- to three-hour excursion away from the LM, the men take pictures and collect up to 65 pounds of lunar soil and rocks to bring back to earth in tightly sealed aluminum cases. They hope to set up an instrument to analyze solar wind, a seismometer to detect moonquakes, and an optical reflector. Laser beams from earth, bounced back from this reflector, will measure the moon's distance to within six inches.

Their visit ended, the astronauts explode the two halves of the LM apart and fire the ascent engine. They rendezvous with their orbiting colleague, crawl back into the command module, cast the now-useless LM adrift, and head for home.

The hazards are nearly over, except for re-entry. But the returning explorers face one more potential peril—lunar contamination. Will they bring back moon organisms? Are lunar materials toxic or lethal to earthlings?

Although most scientists think not, NASA feels that caution is the best policy. So the astronauts go directly from their spacecraft to a transfer van on the recovery ship, then to the Lunar Receiving Laboratory at the Manned Spacecraft Center near Houston for quarantine until 21 days after the men have left the moon.

This new laboratory provides living facilities for the three astronauts and for the staff that will stay with them. It also contains complex arrangements for analyzing and testing the lunar samples (opposite)—even to the point of feeding powdered portions to such diverse life forms as oysters and cucumbers.

Finally, if no contamination shows up, the astronauts will be freed. Then they can say, with Shakespeare's Hotspur, "Methinks it were an easy leap to pluck bright honor from the pale-faced moon!" THE END



ALADDIN'S LAMP OF THE MIDDLE EAST

KUWAIT

By JOHN E. FRAZER

Photographs by DAVID F. CUPP

Where the boom began: Excess natural gas flares from Burgan oil field, perhaps the most productive in the world. Here in 1938 Kuwait's first well gushed into being; the ensuing bonanza hurled a pastoral Bedouin society into the whirlwind of the 20th century. Symbols of the new affluence, automobiles sell so fast that Anwar al-Mulla (right), owner of this experimental Plymouth sports car, has become the largest car distributor in the Middle East.



IT IS A WAVY, gravelly, sunburned desert—but one of the richest deserts on earth. It has no personal income tax, and public telephones are free. It has no fire hydrants, but it can distill 30 million gallons of fresh water daily from the sea. It grows spinach in glass houses without using any soil. It has revolutionized its 200-year-old government without a single rifle shot or hint of violence. And its overwhelming problem is not how to get money but how to spend it wisely.

This is Kuwait—the compact sheikdom at the head of the Persian Gulf (map, page 647). Only a few decades ago this Arab community of traders, seafarers, and nomads relied on a mud wall around its capital city (also called Kuwait) to repel invaders storming across the sands from inner Arabia.

Today, secure and progressive Kuwait, only two-thirds the size of Maryland, is the world's sixth largest producer of oil—after the United States, the Soviet Union, Venezuela, Saudi Arabia, and Iran—and an extraordinary example of the power of money to transform a nation.

"If we had not had this development of nature, thanks be to God," says Rashid Abdulaziz Alrashid, Under Secretary of the Kuwait Ministry of Foreign Affairs, "we probably all would be pearl divers."

Rain No Longer a Cause for Rejoicing

I had flown to Kuwait by way of India, and my first view of it was properly symbolic. Far below I could see the Persian Gulf's liquid embroidery scalloping the Arabian sands. Then I noticed a thin black line penciled across the desert—an oil pipeline. In the gulf a laden tanker, white spindrift blowing round the bow, plowed in sunshine toward some distant refinery.

To my astonishment it was raining when I landed in Kuwait—a flash downpour—and, even more astonishing, hardly anyone paid the rain the slightest attention. Bashar Abdul Rahman, of the Ministry of Guidance and Information, was waiting for me with an air-conditioned car. The driver, a tall Bedouin in a long, flowing white robe, or *dishdashah*, and a crisp white headdress, stepped gingerly around the glistening puddles to take my luggage from the Iranian porter. We splashed away as if water were the most plentiful commodity of the desert.

In this arid region of Arabia, where a scant one to six inches falls in a year, any rain at all was once cause for rejoicing. The people of the capital used to hoard rain water in their rooftop tanks or big courtyard reservoirs. To supplement this chancy supply, 96,000 gallons of water a day was boated to Kuwait City from the Shatt al Arab in Iraq, a hundred miles away, by the famous Kuwaiti teak *booms*, or dhows. These ships anchored outside the harbor until sediment settled in the tanks on deck; then they berthed at a jetty, and *candaris*, or water carriers, peddled the crystal cargo from goatskin bags. Other vendors sold it from donkey carts or trucks.

Science Solves the Water Problem

I soon understood why a thunderstorm and sudden torrents of rain no longer excite Kuwaitis. When fortunes from oil began to soar in the early 1950's, one of the nation's first major expenditures was construction of the world's largest water distillation plant. Now, in ways hardly dreamed of in an often-parched past, income from oil is helping slake the thirst of Kuwait's 262,000 citizens and 270,000 foreign residents.

I went with Bashar a day or so after my arrival to inspect the mammoth power-and-water complex at Al Shuwaikh, southwest of the city. After introductions and a cup of Kuwait's potent coffee, I listened as Tawfiq Hassan, one of the plant engineers, explained the desalting process.

"The salt water from the gulf is pumped in through six pipes, each of which can handle 1,200,000 gallons an hour," said Hassan. "Then natural-gas heat evaporates the water. We condense the vapor into a liquid again—water in its pure, distilled form. It has no minerals in it, and it's tasteless."

He handed me a brimming glass. "Please try it." He was right—no taste whatever.

"Then we add 5 percent brackish water. This isn't potable by itself, but it gives the distilled water a natural taste, and it supplies a high concentration of minerals and salts."

From Al Shuwaikh the fresh water flows to 22 distribution stations, and trucks deliver it to users (pages 654-5). Prices range from $2.40

Splendor of the Arabian Nights embellishes Kuwait's official guesthouse. Planned as the private pleasure dome of a royal sheik, Al-Salam, or Peace, Palace was purchased by the government for $8,400,000. It witnesses glittering receptions held by and for the Emir. As head of state of this now wealthy land, His Highness Sheik Sabah al-Salim al-Sabah receives an annual income of $18,000,000, but voluntarily returns one-fifth to the national treasury.



to $3.00 a thousand gallons—compared with about 44 cents a thousand in my home town of Philadelphia.

Kuwait added a water strike to its string of oil strikes just a few years ago. Now the manufactured water supply is being augmented by millions of gallons daily from an accidentally discovered underground lake at Raudhatain, near the Kuwait-Iraq border.

I had an inkling of what it was like to get water in the old days when I chatted with Bahar Tirathdas Gidwani, an Indian bank officer, after one of Kuwait's seasonal sandstorms.

"If a storm like that came up suddenly," said Mr. Gidwani, "the dhows from the Shatt al Arab couldn't move out, and sometimes, during a 'red' sandstorm blowing in from Syria and Iraq, no water might arrive for two or three days." Several times thereafter I watched shawls of the gritty particles whirling in from the gulf, becoming so impenetrable that I could not even see the park across the street.

Nowadays the water ships are gone, their usefulness past. Kuwait itself almost floats on a sea of oil, and oil has built the most modern city in Arabia. The field at Burgan, about 25 miles south of the capital, has been called the most productive oil field in the world (pages 636-7 and 665). All

Ancient foe: the weather

KUWAIT, tucked in a blazing corner of the Arabian desert, endures summer temperatures that reach 120° F. Kuwait City, among the world's hottest capitals, claims to be the most air-conditioned. Windstorms frequently sandblast it with choking grit. Below, a combination sand- and rainstorm batters a lonely automobile. Rainfall, a meager one to six inches a year, once called for rejoicing. Now with distilled sea water available, downpours are a nuisance. Holding up their *dishdashahs*, traditional flowing robes, pedestrians (right) aid a cab driver searching for an ignition key lost during a deluge. A floating carpet has run aground on the sidewalk.







EKTACHROME © N.G.S.

Fading fashion envelops a shopper at a supermarket. Robe and veil have been cast aside except by the most conservative women, who seldom leave their homes. This rare exception and her junior-miss daughter select from vegetables largely imported from nearby nations. Kuwait experiments with hydroponics, or soilless farming, in the hope of producing an increasing percentage of its food.

told. Kuwait's proved reserves of crude oil are estimated at more than 10 billion tons—about 15 percent of the world's supply. So plenteous is the flow that the Emir, as head of state, receives a yearly income of $28,000,000 from state revenues (of which he voluntarily returns a fifth). At latest count the nation's annual revenues from oil had skyrocketed to $759,000,000.

Wondrous City Springs From the Desert

How are such huge sums being spent? What is little Kuwait doing with it all?

Any night from the balcony of my seventh-floor room at the Kuwait-Sheraton I could see the vibrant answers in the expanding city's spangles of light. Two decades ago, where I stood was the southwestern limit of the mud-walled capital. Now, illuminated highways spoked out for miles; roofs sprouted an aluminum forest of television antennas; quality shops of Fahad al-Salim Street, glittering below, sold everything from miniskirts to skin-diving equipment. Where, in the tranquil past, Bedouin shepherds had prodded their jostling animals through dusty lanes, there was now a cosmopolitan city of concrete-and-glass office buildings, marble banks, cinemas, public gardens, mosques, hospitals, schools, and lavish houses (following pages).

And not only the physical aspect of Kuwait but also the mellow traditions of its people, their desert ways, and their prospects for the future—all had changed irrevocably, for better or worse.

The Kuwaiti primarily responsible for his country's transformation was a tall, heavily built sheik of imposing dignity—the late Emir of Kuwait, His Highness Sheik Abdullah al-Salim al-Sabah. He assumed office in 1950 as the eleventh consecutive member of the al-Sabah family to rule Kuwait. His younger brother, the present Emir, His Highness Sheik Sabah al-Salim al-Sabah, who began his rule in 1965, is the twelfth (page 646).

Kuwait's revenues from oil were slight at first—an estimated $500,000 in 1946 when commercial production began. But by the early 1950's income had leaped to hundreds of millions of dollars a year.* Sheik Abdullah thereupon made two basic decisions. I heard about the first even before I left America, when I talked in Washington with His Excellency Talat al-Ghoussein, Kuwait's Ambassador to the United States.

"What may surprise you most about Kuwait," the ambassador had said, "is the way oil revenues are distributed. Sheik Abdullah simply decided to buy land from Kuwaiti owners and pay for it at high prices."

Land was constantly needed for new roads, new houses, new office buildings, new schools and government ministries, said the ambassador, and prices began to soar.

"Often the same land was sold and resold, and always at a higher price," he continued. "But the government kept on buying. This was one of the methods the Emir had chosen to distribute oil revenues—and the land purchases continued."

They still continue—though on a limited scale. Since 1953 about $2,500,000,000 has been paid out for land by the Kuwait treasury to more than 20,000 families—about 50 percent of the Kuwaiti citizenry. Only Kuwaiti citizens can own, buy, or sell real estate. Large landholders, including members of the ruling family and leading merchants, became millionaires almost overnight. And even Kuwaitis who owned only small tracts of land awoke to find themselves affluent.

The former Administrator of the American Mission Hospital, Haider Mohammed al-Khalifa, told me, "In 1949, my father bought a plot in the capital for $1,260 and built a house on it for $4,200. In 1961 the government bought the house and land for $105,000."

Nor was that the end of his family's good fortune. Haider and his father and four brothers purchased another plot outside the city wall, near the present International Airport, for $2,100. "We sold that to the government," he said, "for $44,100."

Poverty No Barrier to a Secure Life

But what about those who owned no land—the desert wanderers, the poor of the docks, the laborers and fishermen who toiled for a low daily wage? How have they fared?

Among them are many of the foreigners—mainly Arabs from other lands and Iranians, Indians, and Pakistanis—who make up slightly more than half of Kuwait's population. And many Kuwaitis also fall into the low-income group. The minimum daily wage of government employees is $2.25, and some Kuwaitis as well as foreigners still live in squalid tin shacks on the edge of town.

It was for such Kuwaitis that Sheik Abdullah arrived at his second basic decision:

*See "Boom Time in Kuwait," by Paul Edward Case, NATIONAL GEOGRAPHIC, December 1952.





Posh playground, the Gazelle Club caters to wealthy foreigners and well-to-do Kuwaiti nationals. Drawn by dreams of a share in the riches, outsiders flock to Kuwait in such swarms that they now outnumber the country's citizens.

Touched by the magic wand of oil, the Cinderella city of Kuwait tosses away her crowded mud-walled homes and dons bright concrete-and-glass buildings. The Al Mirgab area, foreground, blends multistoried office buildings with long, low shopping arcades. Retaining the organization of the old *suqs*, or bazaars—a few of which still exist—some buildings specialize: cloth merchants in one, jewelers in another. The Abdullah al-Mubarak al-Sabah Mosque rises from one of Kuwait's more than 150 traffic circles.



KODACHROME © N.G.S.

Rolling out the welcome carpets, the Emir of Kuwait, right, greets a visitor—ruling Sheik Ahmad ibn Ali al-Thani of Qatar, another oil-rich Arabian sheikdom. Grand Chamberlain Mohammed Darwish al-Aradi, center, introduces the visiting ruler to a reception line of Kuwaiti officials and the diplomatic corps; news photographers record the good-will visit.

He determined to create a modern welfare state so that, in due time, no Kuwaiti should lack a home, or a job, or an education, or medical care, or the opportunity to make something of himself.

Camel Herder Commissions an Artist

If, for example, a Kuwaiti's income is too low for a satisfactory level of living, the state grants assistance of $43.50 to $220 a month, depending on the size of the family. More than 7,800 families now receive such financial aid. The state will also help a man with a small income to buy a house.

I dropped in one morning on the Bedouin owner of such a house at Al Jahrah (population 10,400), west of the capital. Hasan Salim, as I will call him, is an erstwhile shepherd and camel tender, a man of quiet humor with the weathered face of the desert dweller. He is now a guard in the Ministry of Education.

His new house has a sitting room, kitchen,



A land Croesus would have envied. Kuwait has increased her revenue more than a thousandfold in little more than two decades. Her people have one of the highest per capita incomes in the world—and pay no personal income taxes. In addition to profits from her own wells, the nation receives half the oil revenues from the eastern Neutral Zone, shared with Saudi Arabia.

sleeping quarters, women's quarters, and a courtyard for his animals. An artist on a stepladder was painting a flamboyant design around a ceiling fan when I arrived. My guide, Sayed Uthman Muzeal al-Saeed, the Civil Governor of Al Jahrah, softly chided Hasan for lavishing $225 on such a florid luxury.

The new owner ignored the mild reproach. "I want my home to be like the homes of other rich men," he said with a laugh.

Nearly 9,000 low-income houses like Hasan's have been provided, and others are being built. The owners can repay the cost in 25 years with as little as $10 a month.

A week or so afterward, I visited a rather more elaborate home when Ibrahim al-Shatti, the talented young Kuwaiti who is Director of the Office of His Highness the Emir, invited me to tea. He courteously sent his car and driver for me, and we left the hotel just in time to escape the late-afternoon rush. This can be a very competitive situation, since



Tomorrow's leaders stroll to class at the new University of Kuwait, envisioned as a center of education and research for the Arab world.

Search for a style added surprising new forms to the skyline in the first decade of Kuwait's building boom. Now architects foresee a return to more traditional Arab design.

Electronic touch to an ancient custom, television becomes the center of attention as Kuwaitis gather for evening tea outside a merchant's home.



KODACHROMES BY TOR EIGELAND, BLACK STAR (UPPER LEFT), AND DAVID F. CUPP © N.G.S.



there are 114,000 automobiles in Kuwait (one for every five persons), and nearly 8,000 of these are taxis.

Mr. al-Shatti lives in Al Khalidia, one of the capital's 16 suburbs, and we sped there along roads lined with eucalyptus, palm, and casuarina trees. More than 850,000 trees and shrubs have been planted to create verdure in the desert, and to serve as screens against sandstorms. Trees in parks and along streets are watered by hand from tank trucks.

Firemen, incidentally, also must rely on transported water. Since Kuwait has no fire hydrants, big tank trucks roll along with the fire brigade to take water to the fire.

Tulips and a Peacock Brighten a Home

"Welcome," said Mr. al-Shatti, unbolting the gate door in the high wall around his residence. In the small garden planted in front with tulips brought from London, a peacock in a cage minced and pranced. Like all Kuwaiti officials, my host wore the national dress, looking far cooler in his white robe than I in my Western business suit.

Inside the two-story house I found quick relief from the dry, blazing heat. Kuwait is probably the most air-conditioned capital in the world, and the al-Shatti residence, like most new homes, was air-conditioned.

Sabika, Mr. al-Shatti's gracious wife, came up to greet me, and later, with the young couple and their three lively but polite sons, I sipped tea and nibbled at cashew nuts and cookies in the living room.

I felt quite at home in the kitchen, with its electric range and refrigerator. Across the

long hall from the kitchen I admired the family room where, my host explained, "we sit on the floor Arab-style and drink our tea and watch television."

Later, in the handsome library, or *maktabah*, I noticed among the hundreds of Arabic volumes a copy of National Geographic's *Wondrous World of Fishes*.

"I used material from it on my TV program," said Mr. al-Shatti, who until recently conducted his own popular Tuesday-night show over Kuwait State Television.

Old Town's Gates Were Locked at Dusk

In the days that now rippled swiftly by, I had many chances to explore the new Kuwait. But like many Kuwaitis themselves, I often felt the lure of the peaceful past. I liked to wander at twilight toward shadowy sectors of the old town, which bulldozers eventually will rip apart.

By the sea in one such area is the hospital of the Arabian Mission of the Reformed Church in America, founded in 1911 and until 1949 Kuwait's only hospital. It has been a state health service facility since 1967.

I asked Dr. Lewis R. Scudder, formerly the hospital's Chief Medical Officer, what Kuwait looked like in the quieter days before oil.

"It was a very simple little town when I came here in 1939," said the American physician, who still lives in the hospital compound. "The wall gates were locked at night; and you had to get a watchman up to let you through. Most houses were one story high, made of mud or coral rock with mud interiors."

When I mentioned this to my friend Bashar Abdul Rahman, he said, "My father-in-law owns such a house. He doesn't live in it any longer but likes to go there and sit in the courtyard sun with his friends. I'll borrow the key."

We soon halted before the house, with one of the massive teak doors justly famous in Kuwait. Bashar opened a small door framed within the larger one, spraddled through, unlatched the big door studded with iron bolts, and bade me enter.

I discovered the house was not one but four—built in a row with front and rear walls common to all. We had entered the first wife's home. A short passageway led to a sun-warmed walled courtyard, shaded by pomegranate and lemon trees. Off the courtyard on three sides opened a number of rooms.

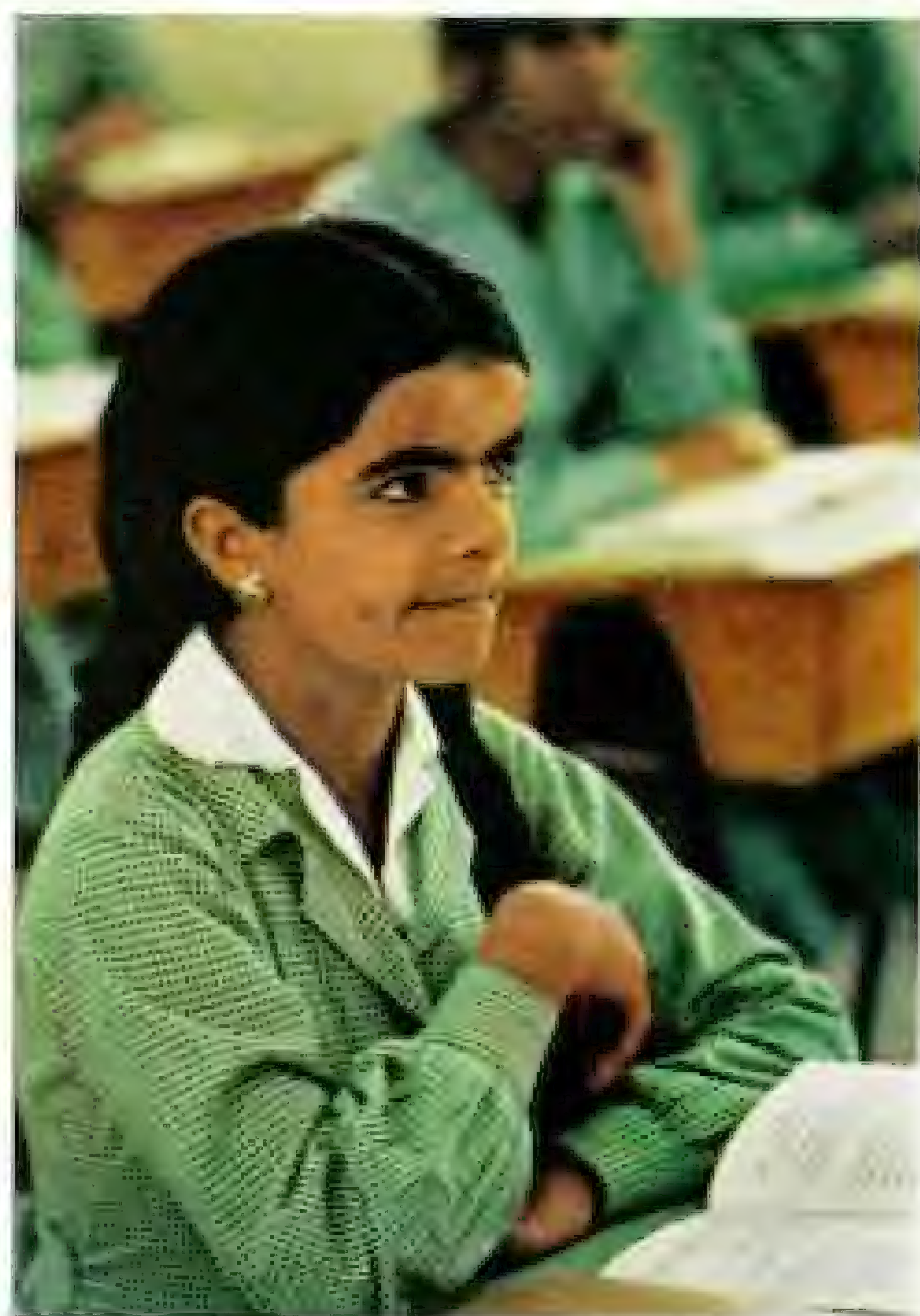
"Each member of the family occupied a room," said Bashar, "and here"—leading me into a large chamber—"was the family sitting room. There would have been a Persian rug

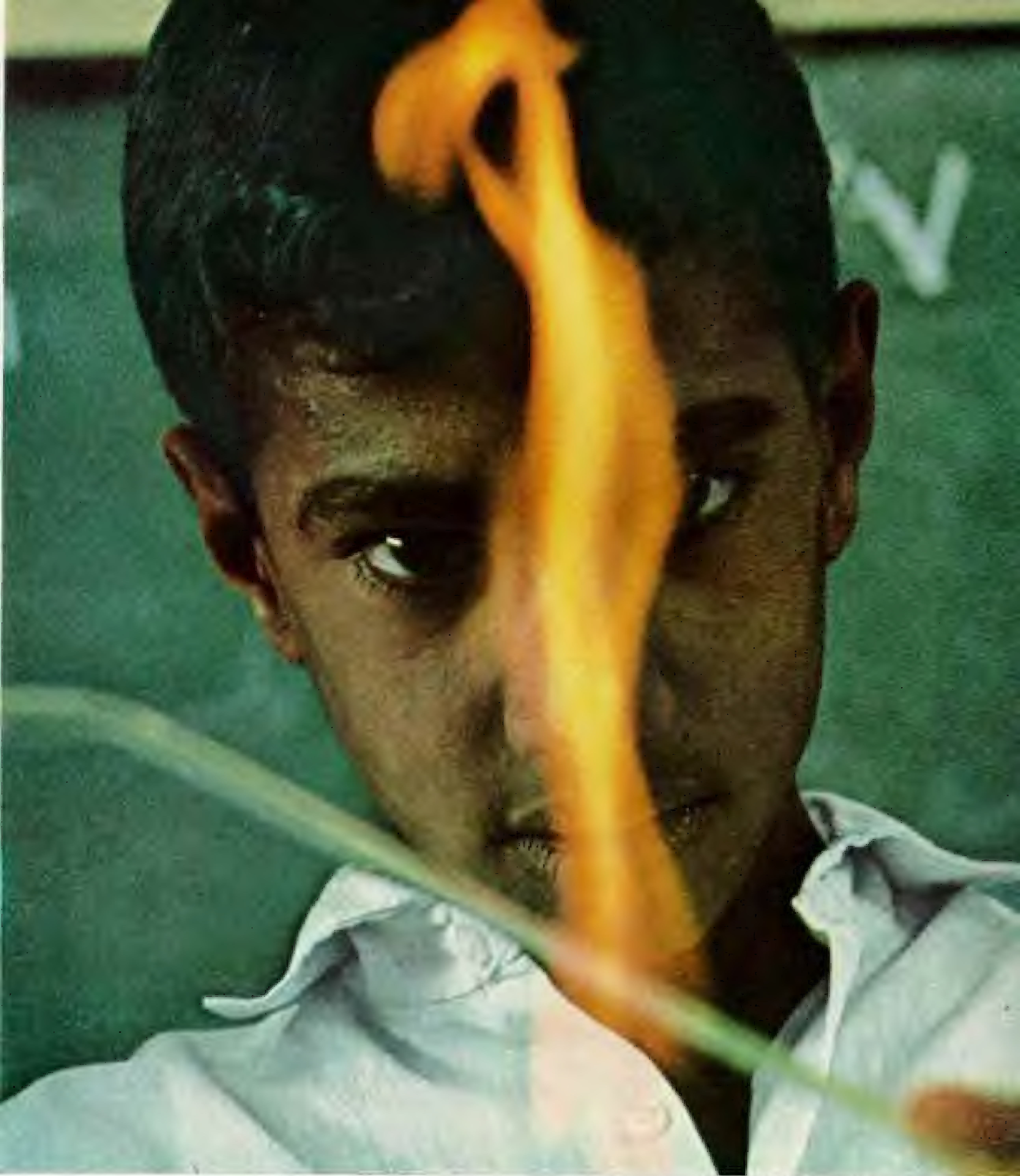


[illegible] © N.G.S.

Egyptian educator, Dr. Zaghloul el-Naggar, a professor at Kuwait University, lectures to a second-year class in paleontology.

Eager to learn, this youngster pays close attention to her teacher at Qadisiya Intermediate School, one of 73 set up to educate Kuwait's girls.





Free tuition, kindergarten to college

FIRE OF CURIOSITY shines in the eyes of a Kuwaiti youth as he prepares for a science experiment at Al-Fayha Intermediate Boys School, bending glass tubing in the flame of a Bunsen burner. To tap the potential of its people, the government budgets a generous portion of oil income—11 percent—for education. Today more than 120,000 students troop to classes in 212 schools. Attendance is compulsory for both boys and girls from 4 to 16 years of age. High-school scholars who maintain high-enough averages receive free college tuition and expenses either at the University of Kuwait or at institutions abroad. As facilities permit, foreign residents may also attend the free university.

on the floor, and long rolled white cushions to lean against."

On the rooftop stood a *bag-dir*, or wind tower, presumably of Persian origin. Two tall vertical slabs of mud brick intersected midway at right angles to catch the wind from any direction and then funnel it down to rooms below.

"Not a bad air conditioner," I said.

Bashar agreed. "Especially at dawn when cool winds blow in from the desert."

Quzi Honors the Special Guest

A door in the courtyard wall admitted us to the yard of the kitchen house. We continued through to the courtyard of the third house, the *diwaniyyah*, a kind of open-air social hall for men of the family, with rail-backed wooden benches in the center.

"My father-in-law and his men guests sat here in the evening to drink tea and coffee and discuss the day's news," explained Bashar. Beyond, in the fourth house, had lived the second wife. The whole compound was, to my mind, spacious, cool, contemplative, and a perfect symbol of a Kuwaiti way of life now gone forever.

I asked Bashar about meals in the old house.

"Breakfast was usually around seven o'clock," he said. "There would be black tea, flat Arab bread, and white cheese—we'd eat mint leaves with this, then boiled or fried eggs. At noon or 12:30 we ate lunch—Kuwait's big meal. Perhaps we'd have *machbus*, lamb and rice cooked with raisins, chickpeas, salt, onions, rose water, and saffron; and with it *dakkus*, made of tomatoes and garlic, sometimes with eggplant added, and hot pepper. Supper at seven or eight o'clock was lighter—perhaps fried *zubaidi*, a prized gulf fish."

To honor a special guest, Kuwaitis serve *quzi*, the national dish. A spring lamb is stuffed before roasting with rice mixed with eggs, almonds, pine seeds, chopped kidneys



Staffed by international specialists, the 700-bed Al-Sabah Hospital was established by the late Emir, His Highness Sheik Abdullah, brother of the present ruler. Here in the hospital laboratory, English technician John Lawrence works with a beam-direction shell, a face mold used in a cobalt treatment for cancer. In 1949 Kuwait opened its first public hospital; today the nation has 11, providing free medical care for all.



Strengthening frail legs with the help of a wheeled walker, a little girl pushes through a clinic for crippled children. More than 100 health-care centers offer medical and rehabilitation services to even the most remote villages. Complete medical records are kept up to date on every citizen and resident of the country.

and liver, salt, and saffron. I feasted on this delicacy, and I can assure you it deserves its reputation as a special treat.

It was a piece of chocolate wrapped in gold foil, however, that introduced me to another aspect of the new Kuwait—the school system. A demure girl of 5 curtsied and shyly held out a box of candy as I entered the principal's office in the Euphrates Kindergarten, one of 43 in Kuwait. (Foreigners must provide their own kindergartens, and do.)

Literacy Rate Has Already Doubled

Later, I watched the new, youngest generation of Kuwaitis dance a wedding dance, paint at outdoor easels, and hop and frisk lightly around a high bush, picking up branches that had been sheared off by the school gardener—practice in helping at home!

Farida Mukhtar, the principal, is an Egyptian. Kuwait imports almost all its schoolteachers, chiefly from Egypt and other Arab countries, and in June a scholarly hegira takes off from Kuwait's International Airport as thousands of them fly home for the holidays.

"We eventually may have the highest percentage of educated people in any country," Faisal A. al-Kazemi, a young official at the Kuwait Planning Board, told me proudly.

I can believe it. There are now 212 kindergartens and primary and secondary schools, big, bright, and impressive, with more than 120,000 pupils, of whom 52,500 are girls (pages 650-51). Education is compulsory from age 4 to 16, and everything is free—tuition, books, clothes, transportation, food. A vast central kitchen prepares lunches for all but the few who go home for noon meals.

Kuwait now also has its own university, with a motto from the holy Koran that poignantly expresses the nation's hope for its youth: "O God, make me more knowledgeable." It is free to all and accepts a limited number of foreigners. Enrollment is 1,300, and by 1970





Stream of trucks lines up for water at a pumping station in Kuwait City. Lacking surface water, Kuwait built its first large-scale sea-water distillation plant in 1953. Now three plants, fired by natural gas, can provide 30,000,000 gallons a day. The trucks deliver to homes, pumping the water into rooftop storage tanks. In 1960 a vast underground reservoir was found near Raudhatain, supplementing the distilled supply.

Filling station attendant pours water, not gasoline. Truckers buy water at $1 per thousand gallons and sell it for as much as $3.



KODACHROMES BY TOR EIGELAND (ABOVE) AND DAVID F. CUPP © N.G.S.

may total 2,000 students from Kuwait, the Trucial States, and elsewhere in the Arab world (page 648).

Meanwhile, high-school graduates whose grades average 69 and up may go to a university abroad on a government grant to study subjects not taught at the University of Kuwait. For a Kuwaiti undergraduate student in the United States, the grant is $3,800 a year—plus tuition, transportation to and from Kuwait, and medical expenses.

One result of this educational activity is plain: Kuwait's literacy rate, about 30 percent only two decades ago, is 60 percent today and rising.

Kuwait's health is improving too, thanks to oil. Any Kuwaiti who is sick is treated free. Medicines, X-rays, injections, hospital stay, maternity care, operations—all, with minor exceptions, are paid for by the state. Foreigners receive free treatment too, with the exception of surgery and hospitalization, for which nominal fees are charged.

Kuwait now has 11 government and three private hospitals (pages 652-3). Everybody in the country is registered at a neighborhood clinic, and everybody is health-conscious.

"Formerly, when you asked a Kuwaiti mother to have her child inoculated against smallpox," said Dr. Mohammed Il-Hami, Director of Maternity and Child Welfare Centers, "she would refuse. Now mothers want their children vaccinated against all sorts of diseases—even those for which we still have no vaccines."

Despite all this modernization, Kuwait still respects its hardy past. The most breathtaking trade—literally—in old Kuwait was pearl diving, but only rarely now does a ship put out on the hazardous, exhausting hunt for pearls on the gulf's coral reefs.

I found a former diver, Rashid al-Jaimaz, and he told me about the men and ships that sailed the pearling grounds in quest of fortune.

"We would set out in May," recalled Rashid, "sailing to Dubai on the coast. We had a crew of 30—15 divers, *ghes,* and 15 haulers, *syub.* Divers and haulers worked in teams of two, and each man knew the other well."

The pearling ship had a single deck, and on this cramped space the crew worked, slept, and stowed ropes, implements, and gear.

Stone Takes Diver to the Bottom

"When I was ready to dive," said Rashid, "I roped a heavy stone around one foot, slung a rope basket around my neck, and clipped shut my nostrils. I dived, and when I felt my breath giving out, I tugged on the rope and my hauler pulled me up. I dived about 40 times a day. Some divers stayed down for four minutes and some only a minute and a half. An experienced diver would plunge 50 feet."

The pearlers' profits were distributed by formula. "On our ship," said Rashid, "one-fifth, plus the amount spent for food, went to the owner-captain. The remainder was divided into eight parts—five to be split among the divers and three among the haulers." Average earnings for a three-month season might total only $35.

Other Kuwaitis, in that austere past, also turned to the sea for employment. Perhaps as many as 5,000 toiled as fishermen, setting their dome-shaped wire traps or using weirs



and tow-nets to harvest the teeming gulf.

And on the land were merchants, blacksmiths, sellers of grass for fodder, quilt makers, and brokers. Smugglers, too. Low customs duties made it profitable to run goods illegally into nearby lands, a traffic that yielded a considerable share of Kuwait's livelihood.

And out in the desert were the Bedouin, nomadic inheritors of the Arab past, grazing their camels and sheep on camel's-thorn and green-gray *arfaj*. The Bedouin came, pitched their rectangular black tents of goat hair, departed, and came again, wandering unhindered across the open borders of Iraq, Saudi Arabia, and Kuwait.

Tribe Uprooted by Drought and Famine

Many modern Kuwaitis are descendants of the al-Sabahs, the al-Khalifas, the al-Zayids, and others of the Aniza tribe who in the 18th century came to this coastal site from their homeland in central Arabia, which they fled because of drought and famine. Here they founded a new Arab community or joined one already established, and around 1756 the chief of the al-Sabah family, thereafter known as Sabah the First, was chosen Emir.

Of Kuwait's more modern history I had some insight when I visited the Red Fort at Al Jahrah. This oasis town was the scene in 1920 of a fierce battle between the forces of the fanatical Faisal al-Dawish of central Arabia and besieged Kuwaiti soldiers.

I walked the parapet of the mud-walled fort, open to the sky and hardly larger than three tennis courts. Sayed Uthman Muzeal al-Saeed, the Civil Governor, who showed me around, pointed to a heavy wooden door.

"Back of that," he said, "our soldiers stacked heaps of dates as a barricade."

Earlier, the Emir Sheik Salim ibn Mubarak al-Sabah (1917-1921), fearful of assaults on his capital, had ordered a wall 5 miles long and 14 feet high to be built around Kuwait City. But Faisal's forces were repulsed at Al Jahrah, and the wall was not needed. Now



Tableau of change: A Bedouin pitches his tent in faceless sand, and a visitor comes to call in a Volkswagen. With the government's policy of offering employment to all nationals, more and more nomads leave their precarious existence in the desert for permanent homes in the cities. But a few still wander unfettered, freely crossing the borders of Iraq and Saudi Arabia. With the first fall of life-giving rain, they fold their tents to travel with their flocks from one grazing ground to another in a manner little changed since the days of Abraham.



KODACHROMES BY DAVID F. CUPP © N.G.S.

Milk from cows instead of camels arrives at a Bedouin's tent, a daily delivery chore because of lack of refrigeration. Here the milkman shows a tribesman how to open the unfamiliar wax-paper carton. When encamped near towns, the Bedouin receive cow's milk from dairies. Some milk is imported in powdered form and reconstituted into liquid in the city. On their treks through the desert, the nomads still depend on their camel herds for milk.



Telltale mustache curls from the mouth of a small daughter of the desert, drinking milk just sold to her father by the delivery man from the city.



the wall is gone, bulldozed down in a few afternoons in 1957, but the five gates, relics of danger and warfare, still stand.

Soon after the battle of Al Jahrah, Kuwait's borders were fixed by the treaty of Uqair. Kuwait, which had been under British protection since 1899, seems to have had little to say about the demarcation of her own boundaries at the 1922 conference between Sultan Ibn Saud of Nejd in Arabia and Sir Percy Cox, Great Britain's High Commissioner for Iraq. Territory which Kuwait claimed was sliced off for Ibn Saud, and Ibn Saud, in melancholy turn, lost land to Iraq.

Ironically, neither the British High Commissioner nor the subdued Arab sultan, though suspecting the presence of oil in this general region, realized they were cutting up some of the world's most valuable real estate. Sir Percy picked up a red pencil and drew Kuwait's new southern boundary line inland from the gulf—enclosing, unknown to him then, the Burgan area, that El Dorado of Middle East oil. The Neutral Zone, which the treaty carved out of the old Kuwait sheikdom south of the border, also proved rich in oil. It is now administered by Kuwait and Saudi Arabia, who share its profits half-and-half (map, page 647).

Oil Helped Keep the Camels Running

Though they could not know its ultimate value, the Kuwaitis themselves had suspected the presence of oil in their country long before drillers tapped it. "Divers would bring up a kind of asphalt from rocks off the Neutral Zone," said Ahmed Sayid Omar, Chairman and Managing Director of the Kuwait National Petroleum Company. "Then the Bedouin would boil it and smear it on their camels as a poultice for mange."

Earlier in the century the Emir Sheik Mu-



Desert luxury: Kuwaiti businessmen rest during a hunt near the Saudi Arabian border. After a cup of strong cardamom-flavored coffee, the men drive out in open cars with their falcons and shotguns, searching the scrubland for *hubaras*, or lesser bustards. These favorite game birds arrive in the fall when sparse rains turn the scrub a delicate green.

Swathed against the sun, a falconer holds his bird hooded until the hunt begins. Then with hood removed, the keen-eyed falcon spots a bustard's movement in the bush and takes wing. A series of swooping dives usually dispatches the quarry or flushes it for the hunter's gun. The falconer retrieves it for a future feast. So honored is this traditional sport that a falcon adorns the nation's official seal.

barak ibn Sabah al-Sabah (1896-1916) offered to dispatch one of his sons to show a British dignitary "the place of bitumen in Burgan." I saw what is apparently that place—an oval depression in the desert where chunks of oil-saturated sand still blacken the surface. Here was desert gold just waiting to be extracted!

But nothing happened until a man had a perplexing dream.

To understand the strange tale, you must know the background: On December 23, 1934, the Emir Sheik Ahmad al-Jabir al-Sabah (1921-1950) granted a 75-year concession to the Kuwait Oil Company Limited. The engineers started drilling in 1936 at Bahrah on the north shore of Kuwait Bay, but the well was dry, though it cut 7,950 feet into the earth. The drillers then shifted about 35 miles south to a site at Burgan and in May 1938 completed another well which tested at more than 4,000 barrels a day. Subsequently, they drilled eight more, also bonanzas. There was no doubt whatever of the immensity of the sheikdom's riches in oil.

Why did the drillers shift to Burgan? Mrs. Violet Dickson, who still lives in Kuwait, gave me an eerie explanation. Mrs. Dickson is the widow of the late Lt. Col. H. R. P. Dickson, British Political Agent in Kuwait and afterward appointed by Sheik Ahmad to be Chief Local Representative for the Kuwait Oil Company.

Dream Held Key to Oil Bonanza

"One morning in early 1937," said Mrs. Dickson, "my husband woke up and said to me, 'I've had the most unusual dream. I want you to write it down.' This was the dream: He and I were living in a bungalow in Kuwait, and one day after a violent sandstorm he noticed that the wind had carved out a hole by a *sidr* tree in the compound. In the hollow

was a sarcophagus, and when he and I approached it in the dream, we saw a figure wrapped in an ancient, yellowed cloth.

"To our amazement the figure seemed slowly to come to life—it was a beautiful young woman. We took her into the house, and the maid and I washed her and dressed her. When we went outside again and sat near the sidr tree, we heard men shouting in the distance. As they approached, she became frightened and spoke to us in ancient Arabic: 'My life is in danger,' she said. The strangers seized the girl and tried to bury her alive. Colonel Dickson sprang to her aid, knocking down the leader of the group, a bearded man. The others fled, and he and I led the girl back into the house. Then he awoke."

Colonel Dickson described his strange experience to Umm Mubarak, a Bedouin woman famous as an interpreter of dreams. She informed him that the young woman in the sarcophagus, wrapped in yellowed grave clothes, represented a wealth of oil buried in Kuwait. The hostile men were foreigners who wished to prevent its discovery. Moreover, said Umm Mubarak, Colonel Dickson should go to the drillers at Bahrah and advise them to abandon the well and proceed instead to Burgan. There, by a lone sidr tree, they would find the black gold.

Dickson did tell the oil drillers, and was politely ignored, as might be expected. But when, months later, he recounted the dream at a meeting of oil executives in London, one

The heirs of Sindbad

SHIPWRIGHTS and sailors still practice their crafts in Kuwait, but the ancient ways are vanishing. Today only a few small dhows (right) still ply local waters in search of fish.

Once, great fleets of lateen-rigged dhows followed the winds across the Persian Gulf, Arabian Sea, and Indian Ocean, bearing cargoes of dates from Iraq, cloves from Zanzibar, and exotic woods from India.

"Of all Arab dhows," wrote veteran sailor Alan Villiers, "I thought the big Kuwait *booms* had no equals for beauty, sound construction, seaworthiness, and ease in handling."

Kuwaiti shipwright Ali Abdullah Abdul Rasool builds in the traditional manner. Here his workmen shape a *lanj*, or launch. Curved logs of teak, imported from India, form the ribs. The Kuwaitis pass the art of shipbuilding from father to son. Using no blueprints, they carefully saw each plank and fit it by hand. Such skillfully crafted ships often last more than a century.





A ruler's gift to his people, democratic government came into being in 1962 when the late Emir Abdullah established a constitution and a 50-man National Assembly. The Emir's choice of a successor, always a member of his family, must be approved by the lawmakers; a distant cousin, Sheik Jabir al-Ahmad al-Jabir al-Sabah, has already been endorsed as Kuwait's next ruler.

Disdaining the microphone, legislator Zaid al-Kazemi, whose district includes Faylakah Island, speaks before the Assembly.





of them, himself a believer in dreams, cabled instructions to the party working in north Kuwait to start operations at Burgan. There, by the sidr tree, they found oil.

On June 30, 1946, the Emir Sheik Ahmad turned a silver-handled valve at the site that is now Mina (Port) al Ahmadi, and oil from the Kuwait desert began to flow into the tanker *British Fusilier*. It has been flowing ever since (pages 664-5).

World's Largest Tankers Drink Their Fill

Today five oil companies in Kuwait and the Neutral Zone hold concessions to extract liquid wealth not only from beneath the sands but also from wells drilled under the gulf. They represent United States, British, Dutch, Japanese, and Spanish interests as well as Kuwaiti. By far the largest is KOC, the Kuwait Oil Company Limited, in which the British Petroleum Company and the Gulf Oil Corporation of the U. S. are equal partners.

James E. Lee, an American, is Managing Director of KOC in Kuwait. In his offices at Al Ahmadi, the pleasant, landscaped oil town near the wells and the port, he told me early last year of his firm's exciting new plans.

"A number of oil tankers nowadays exceed 100,000 tons capacity," said Mr. Lee, "but Gulf Oil, one of our two partners, has placed orders in Japan for six vessels of 326,000 tons each. These will be the world's largest tankers, and Kuwait will be the only country with facilities to load them. But they'll be too big for piers at Mina al Ahmadi, so we're building a loading platform nine and a half miles out in the gulf, in water 93 feet deep at mean low tide."

The first giant tanker took its initial load from the new platform last September.

Ideas about how to diversify Kuwait's oil economy are blooming everywhere. "They're growing spinach in the desert," a businessman assured me, and one morning I drove out to



the Kuwait Experimental Farm near the airport to inspect the unit that makes this agricultural wonder possible.

Subhi R. Attar, in charge of the hydroponics project, described the science for me. Seedlings, he said, are planted in a mixture of gravel and vermiculite, and irrigated with a nutrient solution.

"We're raising 17 kinds of vegetables," he said; "leaf crops like spinach and Swiss chard; root crops like turnips, carrots, and beets; and fruit-bearing vegetables like cucumbers, tomatoes, eggplants, and peppers. Later we plan to grow grapes, bananas, and mangoes.

"This is an experimental unit"—we were walking slowly through a humid greenhouse drenched in tinted sunlight—"but we are building a permanent five-acre unit which will be the first major commercial hydroponics farm in the Middle East."

Mr. Attar showed me a hybrid tomato—the Fantastic—growing on plants 10 feet high. Five hydroponic acres, he estimates hopefully, will yield a million pounds of tomatoes in a two-crop season, compared with 200,000 pounds on the same acreage of soil. Private business, it is planned, will establish new farms, cashing in on the research done here.

Chickens Thrive on Dates and Corn

Adjoining the hydroponics unit is its new country cousin, the airponics unit. Here, tomato seedlings are inserted into apertures in tubular ducts standing from floor to ceiling—something like a child's jungle gym. A solution of water and chemicals washes over the roots for one minute out of every five. The wet roots provide all the nourishment, and within three months a tangle of vines laden with juicy red tomatoes interlaces the ducts.

The country is currently raising 6,500 cattle and 2,150,000 chickens. The Kuwait Experimental Farm is trying fledglings on a mixture of date mash and bran or yellow corn. The

farm specialists hope the experimental date diet will set a new standard for poultry nutrition and save money too.

Kuwait's wealth is building the future not only of the nation but also of her Arab neighbors. The Kuwait Fund for Arab Economic Development has lent millions of dollars to help finance 16 projects—including a 45-mile railway line in the Sudan, steam units for an electric grid in Tunisia, phosphate mines in Jordan, and an oil pipeline in Algeria.

Since their Six Day War against Israel in 1967, Egypt and Jordan have received millions from Kuwait to rebuild damaged areas. Kuwait has also provided 24 schools in the various Persian Gulf emirates, and the late Emir of Kuwait, Sheik Abdullah, donated the funds to build mosques in the Yemen. The latter gift underscores the fact that Kuwait, by law, is an Islamic state. The constitution begins, "In the name of Allah, the Beneficent, the Merciful," and Article 2 declares that the state religion is Islam. There is a ministry to advance the cause of Islam in Kuwait and abroad. It maintains the nation's mosques, of which there are 235, and provides the imams, or prayer leaders, for them.

Nevertheless, the Kuwait constitution, which was the gift of Sheik Abdullah to his country in 1962 (the year after Kuwait gained complete independence from Great Britain), protects the free exercise of religion. Protestants, Roman Catholics, and members of other Christian churches in Kuwait, virtually





EKTACHROME (ABOVE) BY TOR EIGELAND, BLACK STAR; EKTACHROME BY DAVID F. CUPP © N.G.S.



Kuwait's liquid bank account



A BRILLIANTLY LIGHTED DERRICK pierces the desert sky of the Burgan field, seeking yet another withdrawal from the vast deposit of wealth beneath the sands. With drilling complete, the huge rig will roll to a new site to begin again. At the Ahmadi field, a drilling superintendent (above, left) wears a hard hat decorated with Arab motifs. If his well proves a success, more oil will flow toward Mina al Ahmadi, Kuwait's mammoth oil port (left). Here huge pipelines fill tankers at Kuwait Oil Company's south pier, which can load as many as eight ships at a time. The five companies holding drilling rights in Kuwait and the Neutral Zone produced more than 900,000,000 barrels last year, and the Government of Kuwait received 83 cents for each as its share.



all foreigners, have their own places of worship. The state has even donated the land for a Roman Catholic church.

Sheik Sabah the First and the emirs who succeeded him, up to Sheik Abdullah, ruled as absolute monarchs. Today, thanks to the new constitution, His Highness the Emir heads a more democratic state. "Sovereignty resides in the people," according to this document, and though the office of emir is hereditary, power to rule is shared, in part at least, with the National Assembly (pages 662-3). Few states in history can point to such a peaceful transition from autocracy to constitutional government.

Shampoo Replaces Sidr Leaves

Of the change in the status of women it is less easy to speak. Kuwait, on the surface, remains a man's world. Women do not yet have the vote, but things are not all as they were; modernity has begun to creep into the Kuwaiti woman's outlook.

Mrs. Dickson told me she had recently asked a Bedouin woman whether she still washed her hair with the powdered leaves of the sidr tree. The sidr is a bushy, thorny fruit tree, known also as Christ's-thorn (*Zizyphus spina-christi*) because of the legend that it formed Christ's crown of thorns. Leaves of the tree are dried and pounded, and the powder is then mixed with water to make a lather. Bedouin women, and Mrs. Dickson too, use it as a hairwash.

"Oh, I don't use the sidr leaves any more," said the Bedouin friend cheerfully. "I use shampoo."

But Kuwait, leaping headlong into the mid-20th century, has not escaped problems.

"We have made mistakes," a Kuwaiti merchant prince said to me frankly. Some were due to ignorance; some were thrust upon the emergent, unwary state by what the merchant called "carpetbaggers and slick operators." There were graft and excessive spending, land was wasted, houses often were eccentric in design and shabbily built, and maintenance was and is neglected.

Kuwait now is catching up with some of this. For example, a renascence of Arab architecture adapted to the modern city seems to be in the making. Until recently most of Kuwait's new buildings were like the new buildings in Buenos Aires or Bombay or Baltimore —"international modern" (pages 644-5)—and traditional Arabic design was largely overlooked. Today there is already a perceptible clamor for the return to the courtyard, the arcade, the fountain, and other Arabic and Arabesque motifs.

The impact of easy wealth on the Kuwaiti character also causes concern. "I used to work for my money," said an engineering technician. "Now I only sit for it."

Family relationships have also altered. "The ideas of the father are not the ideas of the son," a social worker commented. "The father may not know anything about the international politics the son studies at college. The affluent son, with a car and money to burn, doesn't realize how hard his father worked in the past, the family perhaps living on a pittance all summer, while the father earned a meager wage as a pearl diver or a fisherman."

Kuwaitis, too, sometimes feel like strangers in their own country, at the mercy of a flood of foreign experts. There are nearly 700 doctors in Kuwait, but only 33 are citizens. Two of them, incidentally, are the first Kuwaiti women doctors.

Nation's Goal: Blend Old and New

The Kuwaitis are proud of the transformation of their land, but the thoughtful ones do not want to lose the values of the past.

"What we wish to preserve," said Under Secretary of Foreign Affairs Rashid Abdulaziz Alrashid, "is first our religion. Then our hospitality. Then our family relationships—the feeling of loving and of trying to help and shelter each other. Then, the simplicity of simple men and the respect of the younger for the older. Finally, our individualism—which is both our strength and our weakness—the spirit of independence that encourages even the humblest man to approach the head of state and complain of an injustice. We hope all these will remain." THE END

New roads to tomorrow lance into the desert in search of future towns. Thirty years ago Kuwait had no paved roads and few automobiles. The power of oil put its feudal society on wheels and sent it down the path of progress. Since the photograph was taken, this highway has been finished, giving Kuwait City an expressway to the International Airport and burgeoning suburbs, its costly construction a testament to faith in the future by a dynamic young nation.

Retracing John Wesley Powell's Historic Voyage Down the Grand Canyon

By JOSEPH JUDGE

Photographs by WALTER MEAYERS EDWARDS

Both National Geographic Staff

OUR PONTOON RAFTS, the *Grand* and the *Green*, ease down a wind-raked Colorado River. Sheer 3,000-foot walls lift to the sky on either side, flying from gigantic red battlements the wild clouds of an August thunderstorm. Ahead, the swift caramel-colored waters seem to vanish at a bright line. Only an occasional spit of spray beyond, and an angry growl in the throat of the Grand Canyon, warn of the danger ahead.

The growl grows to a roar as the current sweeps us onward. Now the thrashing tops of "rooster tails," where the river explodes against unseen rocks, rise into view. In another moment we are at the brink and look down upon Lava Falls Rapids in all its fury.

"Hang on!" yells Ron Smith, pilot of the *Grand*. Fists tighten on ropes lashed across the plywood deck. Then we slant to the right, the fat rubber nose tilts sharply, and we drop into the thundering maelstrom (pages 670-71).

A hissing wave slams aboard with the force of a fire hose. Buried in a seething brown torrent, the bow struggles upward like a fish breaking the surface. Now we leap to the crest ahead and slide again into a chasm of churning foam. The *Grand* buckles and shudders as angry waves wrench at the ropes, flail the rubber bags holding our supplies, swamp the cockpit where Ron steers with the straining outboard motor.

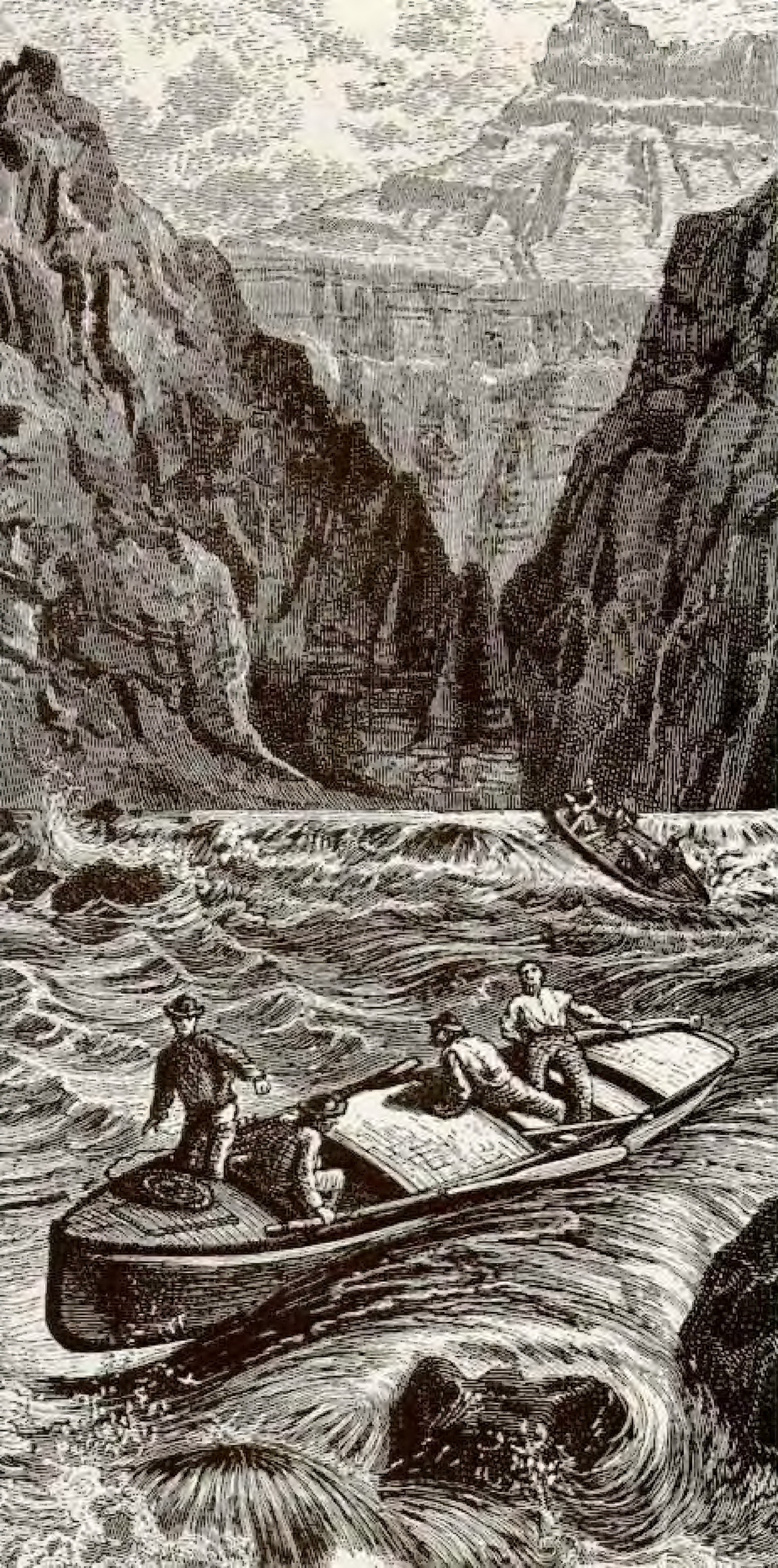
We drive toward a huge rock of lava blocking the river near the right bank. Its glistening black flank seems to rush at us; in another instant we pile against it. The boat tilts crazily on the raging waters.

Then we are blown clear and washed down through tumbling tail waves to the safety of the lower river. The worst of the canyon's rapids lies behind us.

Last summer our small National Geographic Society expedition battled mighty Lava Falls Rapids and more than 200 others on the Colorado River during a 300-mile voyage through Marble and Grand Canyons. Our destination: a rendezvous with history.

It was in the summer of 1869 that a band of 10 intrepid men, led by Maj.

ENGRAVING FROM "CANYONS OF THE COLORADO," BY J. W. POWELL, PUBLISHED 1895 BY FLOOD AND VINCENT



Riding the fury of the Colorado River, two of Maj. John Wesley Powell's four boats lunge through the Grand Canyon. Powell's epic 1,000-mile expedition down the Green and Colorado just 100 years ago unveiled the West's greatest wonder.

In Powell's wake, a neoprene raft of the National Geographic's commemorative expedition bounces through Lava Falls Rapids (next pages). Two such craft made a 300-mile voyage down Marble and Grand Canyons. Left to right: John Evans, Ron Smith, and the author. A remote-controlled camera rides the foredeck. ▶

[illegible] BY WILLIAM BELANAY, JR. © N.G.S.


GRAND



John Wesley Powell, a one-armed veteran of the Union Army, became the first to master the Colorado River and its unmapped canyons. Their journey through the last important unexplored region of the West, their courage in the face of the unknown, the tragic fate that three of them met on the very eve of triumph—all these are now a part of our Nation's heritage.

Departing from Green River, Wyoming, on May 24, 1869, Powell pushed his small flotilla of four boats through a 1,000-mile gantlet of canyons that to this day carry the names his party gave them: Flaming Gorge, Red, Kingfisher, Lodore—where one boat was dashed to pieces—Desolation, Cataract, Glen.

In early August, Powell's party arrived where Lees Ferry, Arizona, is today. Burned by desert sun, drenched by almost daily thunder squalls, their energy sapped by constant portaging of the heavy boats, the explorers faced murderous Marble Canyon and beyond it the awesome void of the Grand Canyon.

Parts of the Colorado today lie pooled behind huge hydroelectric dams, but the 240 miles below Lees Ferry remains much as it was then. Glen Canyon Dam, 15 miles upstream, releases enough water to keep the river as high as it was that summer of 1869.* We intended to commemorate Powell's voyage by following his wake through Marble and Grand Canyons (maps, pages 676 and 690-91).

Rafts Named for Parent Streams

Ron Smith, a strapping veteran of western river-running, held out a strong hand to help me aboard our pontoon raft, the *Grand*.

"Welcome to the poor man's *Kon-Tiki*," he said. "It's not much to look at, but there's one thing about it I like—it floats."

Our party was divided equally between the *Grand*, christened with the old name of the headwaters of the Colorado, and its sister raft, named for the Green River and piloted by Art Gallenson. Naturalists John and Frank Craighead, with Frank's son Lance, came down from Yellowstone to add to their study of wild rivers by running one of the wildest of them all. When photographer Walter M. "Toppy" Edwards and I arrived, Mike and Kenny Garrett, sons of National Geographic Assistant Editor W. E. Garrett, were helping to load the supplies aboard.

Handling the bow lines were Bill Belknap, an old hand on the Colorado,† and geologist John Evans, on leave from the National Aeronautics and Space Administration. John had participated in the first climb of the Vinson Massif, Antarctica's highest mountain.‡ Fran Belknap and Loie Evans signed on, to our delight, as camp cooks.

Gift of Mud From Distant Buttes

The riverside willows of Lees Ferry waved a farewell as the *Grand* and *Green* drifted out onto a quiet river. We bobbed momentarily on the riffle at the mouth of the Paria, and it tossed a few tentative splashes into our laps. That little river, draining miles of high plateau country, was steadily pumping mud into the Colorado's green current.

Ron leaned over and scooped up a cupful of the brown water, tasted it, smacked his lips, and handed the cup to Mike Garrett.

"Here, Mike, get used to our well."

Gradually but firmly the western cliffs rose against the sun. We drifted under the high silver arch of Navajo Bridge, which carries U. S. 89A across the gorge. Then the high limestone walls drew together and closed gently behind us. We were locked from that time on in the fastness of the canyons.

The long sculptured aisle of Marble Canyon has been so cleanly cut into the plateau by the river, grinding for 10 million years with rocks and pebbles, that it seems machine-tooled. During its 60-mile passage through Marble Canyon, the Colorado drops some 400 feet. We were riding down a staircase of rapids, step by foaming step into the earth.

Bill Belknap, sporting a grizzled beard, brought along the experienced river-runner's duffle—swimming trunks, toothbrush, tennis shoes, shirt, pants, and a copy of Powell's

*See "Lake Powell: Waterway to Desert Wonders," by Walter Meayers Edwards, GEOGRAPHIC, July 1967.

†Mr. Belknap described an upstream run of the Colorado in jet-powered boats in "Shooting Rapids in Reverse!" NATIONAL GEOGRAPHIC, April 1962.

‡See "First Conquest of Antarctica's Highest Peaks," by Nicholas B. Clinch, GEOGRAPHIC, June 1967.

Beyond the river's roar, a pool of silence. Discovering this hushed limestone sanctuary at Shinumo Wash in Marble Canyon, the Geographic expedition christened it Silver Grotto. Canyon trekkers no longer need fear the "Great Unknown," which struck terror into the hearts of Powell's men. "What falls there are, we know not," he wrote, "what rocks beset the channel . . . what walls rise over the river, we know not."



IN A NICHE OF TIME, *the Geographic's river-runners glide down a placid stretch of the Colorado in Marble Canyon, northern entrance to Grand Canyon. Man-dwarfing cliffs rear ever higher as the river plunges into the rocky abyss of the ages. Each stratum of stone marks a page in earth's biography.*

KODACHROME © N.G.S.





Tamed by dams upstream and down, the Colorado still runs free in Marble and Grand Canyons. Powell's 98-day trip from Green River, Wyoming, ended where Lake Mead now brims.





Evening camaraderie and a driftwood fire create a pocket of cheer in the depths of Marble Canyon. Gathered here, left to right, are expedition members John Evans, Fran Belknap, Ron Smith, Lance Craighead, Loie Evans, Art Gallenson, John and Frank Craighead, Mike and Kenny Garrett, and author Joe Judge. After a day of wrestling the rapids, all look forward to sleep lulled by murmuring wind and rushing water.

Muddy but potable: Bill Belknap and Mike Garrett pour river water into the expedition's handy Sportyak. After the silt settles for 20 minutes, drinkable water can be skimmed off. It is often used without chemical treatment, but the National Park Service recommends adding a drop of iodine per cup.



EKTACHROME BY WALTER MEAYERS EDWARDS © N.G.S.

book, *The Exploration of the Colorado River.*

Now, after we banged through Badger Creek Rapids, Bill gruffly delivered a passage from Powell's journal. The words came to life as we beheld again the places he discovered.

"And now," Bill read, "the scenery is on a grand scale. The walls of the cañon, 2,500 feet high, are of marble, of many beautiful colors, and often polished below by the waves. . . . At one place I have a walk, for more than a mile, on a marble pavement, all polished and fretted with strange devices, and embossed in a thousand fantastic patterns."

Below big, rough Soap Creek Rapids, we found such a place—slabs of polished limestone overlapping like giant black-and-white pancakes. The sun rode high and made a caldron of the canyon as we climbed onto the burning pavement.

John Evans and Ron Smith stayed behind, dousing the rafts with water. Ron was concerned that the air inside, expanding in the sun's heat, would burst them.

On a small ledge we found one of Marble Canyon's grim mementos—an old inscription chiseled into the face of a rock:

F. M. BROWN
PRESIDENT DCC & PRR CO.
WAS DROWNED JULY 10, 1889
OPPOSITE THIS POINT

It was the tragic end of another of those large-scale dreams that so many men brought to the canyon country, only to be broken by it.

Frank Mason Brown, a Denver businessman, was encouraged by Powell's voyage to try something incredibly difficult: to build a railroad to San Diego through the Grand Canyon. He formed the Denver, Colorado Canyon and Pacific Railroad Company, and set out in the spring of 1889 to survey the route.

In the small rapid below Soap Creek, at Salt Water Wash, Brown's boat went over. His oarsman was thrown into the current and swept to safety, but a whirlpool sucked Brown under. When, a moment later, engineer Robert

(Continued on page 684)

Grand Canyon: museum of the ages


1. Primeval mountains

TO LOOK INTO THE GRAND CANYON is to peer over the brink of eternity. Far, far down in the Inner Gorge rise dark walls containing igneous rock beneath sediment deposited as long as two billion years ago by grit-laden winds and long-forgotten seas. Titanic geologic forces crumpled and contorted these layers, welding them into hard, banded Vishnu schists and thrusting them up into an immense mountain range about 1.7 billion years ago (1). Later, molten rock intruding through the schist cooled and hardened to form veins of pink granite.


2. Undersea deposits

Mighty as were the primordial mountains, millions of centuries of erosion flattened them to a plain, and the plain then sank below sea level. Once again shallow waters flowed and ebbed across the region; miles-thick layers of sediment slowly built up, and again molten rock welled upward from the earth's interior (2).


3. Second mountain range

Convulsions in the earth's crust about a billion years ago cracked these layers and the schist beneath them, creating huge fault blocks (3) that tilted and shouldered upward to form a second great mountain range. This, too, eventually fell victim to the relentless onslaught of rain, wind, and frost, finally being worn almost entirely away. Its rocky remnants, called the Grand Canyon Series, lie wedged at angles between the Vishnu schist and horizontal upper layers (4).

Some 600 million years ago the last great period of sediment-building began. This is the period whose record is so clearly written in the lines of the canyon's stratified walls (painting, opposite).


4. Canyon cutting begins

At times the surface in this region sank beneath invading seas. Deposits of mud gradually hardened into layers of shale, and the remains of countless marine organisms sifted to the sea bottom, building up tiers of limestone hundreds of feet thick. At other times earth's restless crust uplifted. Mighty sand dunes undulated across the exposed surface, sheathing it with thick layers of sandstone.

In this way there gradually emerged a 4,000-foot-thick stone layer cake resting on a deep plate of Vishnu schist. As geologic forces lifted the cake higher above sea level, new strata ceased to form and erosion began nibbling off the topmost layers. Then, about 10 million years ago—a mere drop in the bucket of time—streams that became the Colorado River started cutting into the layered strata.

At an almost infinitesimal rate—averaging less than an inch a century—the river finally sliced through the many layers and into the Vishnu schist (5). Erosion, patiently gnawing away at the walls, has combined with the river's ceaseless cutting to create the ever-widening, ever-deepening chasm we know today as the Grand Canyon.


5. Present canyon

KAIBAB LIMESTONE
300 feet thick

TOROWEAP FORMATION
(SANDSTONE AND LIMESTONE)
250–300 feet thick

MIDDLE PERMIAN
220 MILLION YEARS AGO

COCONINO SANDSTONE
300–350 feet thick

HERMIT SHALE
300 feet thick

SUPAI FORMATION
(SANDSTONE AND SANDY SHALE)
800 feet thick

EARLY PERMIAN
240 MILLION YEARS AGO

REDWALL LIMESTONE
450–500 feet thick

MISSISSIPPIAN
300 MILLION YEARS AGO

DEVONIAN
350 MILLION YEARS AGO

MUAV LIMESTONE 100 feet thick

CAMBRIAN
500 MILLION YEARS AGO

BRIGHT ANGEL SHALE
450–650 feet thick

TAPEATS SANDSTONE
225 feet thick

GRAND CANYON SERIES
(SANDSTONE, SANDY SHALE, AND LIMESTONE)

VISHNU SCHIST

PRECAMBRIAN
2 BILLION YEARS AGO

GRANITE
INTRUSION


Warm shallow seas nurtured the creatures whose shells and bones slowly built up Kaibab limestone.


A harsh world of burning sun, droughts, and periodic floods characterized the epoch when Hermit shale formed.


Armored trilobites dominated the undersea realm whose remains lie embedded in Bright Angel shale.

Record of life: A shark's tooth, a lizard's footprint, a broken shell—from such hints paleontologists interpret the obscure Rosetta stone of evolution. Geological cross section, left, depicts the stairway which life climbed from Precambrian times, when only the most primitive creatures existed, to the Permian Period, represented in the uppermost layers of the canyon. Erosion has erased traces of several periods; strata from the Age of Dinosaurs, for instance, once towered above the present rim.

Paintings depict the life of three earlier formations. *Upper:* A two-inch nautiloid extends its tentacles; a primitive shark (known from a single tooth) ghosts past sponges, spiny brachiopods, cup coral, and leaflike bryozoans. *Middle:* Dragonfly with 10-inch wingspread hovers over a semi-arid world of ferns and conifers; early reptiles (based on fossil tracks only) roam the shore. *Lower:* Trilobites, shown life-size, skitter past a rock encrusted with tiny brachiopods; encrinoids, distant relatives of starfish, wave many-fingered crowns.

"**The ages** have been at work on it, and man can only mar it," declared President Theodore Roosevelt on seeing the Grand Canyon in 1903. ". . . keep it for your children, your children's children, and for all who come after you, as one of the great sights which every American if he can travel at all should see." Five years afterward the conservation-minded Chief Executive proclaimed the eastern part of the canyon a national monument.

Congress gave the domain national park status in 1919; this year the park celebrates its fiftieth anniversary. The central section became a national monument in 1932. President Lyndon B. Johnson—on the last day of his administration, January 20, 1969—proclaimed Marble Canyon a national monument, thus giving Federal protection to the entire middle course of the Colorado.

This early-morning panorama from 23,000 feet looks southwest across the time-sculptured gorge to the South Rim. Summer-parched Natchi Canyon at lower right cuts into the flank of forest-mantled Walhalla Plateau.

Distance from rim to rim across the chasm's 217-mile length varies from 4 to 13 miles. The canyon's actual immensity can scarcely be grasped by the human eye and mind, which tend to underestimate its real dimensions. What seems from a distance to be a man-size rock often turns out to be a spire as tall as a 30-story office building. If four structures the size of the 1,472-foot Empire State Building could be stacked one on top of the other on the canyon floor, only the television tower of the fourth would poke above the North Rim.

A French-built Dassault fan-jet Falcon owned by Pan American World Airways flies beside the photographer's plane.

KODACHROME BY WALTER MEAYERS EDWARDS © N.G.S.



THIS PAGE FOLDS OUT



Fount of Hopi legend

SACRED PRECINCT of the Hopi Indians, this travertine dome on the Little Colorado, five miles east of the Grand Canyon, was formed over the centuries from minerals deposited by water flowing from the central vent. Hopis, who call the dome the *sipapu*, say their ancestors emerged from the underworld through the spring's mouth. A flash flood recently eroded the dome's base so that the water now leaks out below; in time, mineral accretions will plug the leak and the spring will flow normally again. Calcium carbonate clouds the striking blue of the stream.

Expedition members (below) examine tiny stalactites at a salt seep oozing from cliff walls not far from the sipapu. Hopis in villages near the Grand Canyon use the crystals in sacred rites.

Legends of gold, not salt, lured Spanish explorer Don García López de Cárdenas, one of Coronado's captains, to this region in 1540. They were seeking the fabled Seven Cities of Cíbola, reputedly paved with gold, but had found instead only poor Indian villages. Led by Hopi guides, Cárdenas probed farther northwest and came upon the insuperable barrier of the Grand Canyon. In its mind-staggering vastness the disappointed conquistador saw only the end of his gilded dreams.





(Continued from page 677)

Brewster Stanton came by, only Brown's notebook was bobbing on the surface.

Just five days later the party, led now by Stanton, hit 25-mile Rapids. The current drove a boat rowed by Peter Hansbrough and Henry C. Richards under an overhanging cliff and capsized it. Both men drowned.

Two nights afterward a violent storm blew through the canyon. "Nowhere," wrote a dejected Stanton, "has the awful grandeur equalled that night in the lonesome depths of what was, to us, death's canyon."

As we ran House Rock Rapids, the afternoon darkened and a rising wind blew silver rain in slanting lines against the shining-wet canyon walls. We tied the boats at the foot of the rapids and scrambled up a steep sand hummock to a rock shelter, where we stood and watched the river change before our eyes.



KODACHROMES BY WALTER MEAYERS EDWARDS © N.G.S.

It thickened into a brown stew churning with logs and branches washed down by the storm. We noticed with alarm that our boats were acting as breakwaters; within an hour an island of jagged timbers was building up against the side of the *Green*, tied upstream. We waded in to fend off the debris.

A tense drama of men and an angry river was played in the light of lanterns and flashlights. Through a long night we pushed and pulled the boats to keep them clear of twin perils—the rocks of the shore and the heavy daggers of wave-borne driftwood.

Explorers Find an Unmapped Treasure

In the cool dawn, bats wheeled overhead and a canyon wren sang its heart out in a tumbling torrent of melody that is surely one of earth's most beautiful sounds. Soon after, Marble Canyon revealed one of its secrets.

At Shinumo Wash, 30 miles below Lees Ferry, Lance Craighead and John Evans climbed a little cliff and made their way around a smooth elbow of rock. They soon yodeled for us to follow. Mike, Kenny, and I climbed up and found John Evans with a rope around his waist. Beyond him and lower down was the mouth of a cavern.

"Grab on," he said, "and let yourselves down slowly." At the bottom of the slope we beheld a breathtaking scene.

The waters of the wash, descending from the Painted Desert that rims Marble Canyon, had hewn out a series of chambers in the limestone. They seemed carved out of the finest silver or pewter; the walls, polished smooth as ivory, closed overhead to narrow skylights.

The first chamber was warm with red light reflected from the far canyon wall. We swam a green pool and chimneyed up through a



Unearthed after 3,000 years, these split-twig figurines formed part of a cache hidden by an unknown people in Stanton Cave, in the new Marble Canyon National Monument. Each ingeniously constructed from a single willow branch, the strange figurines predate by 2,000 years the next oldest class of artifacts in the area. Tiny "spears" piercing some of them suggest that the figures may have been used in magical hunting rites. These four came to light during a recent probe by Dr. Robert Euler (kneeling) of the Center for Anthropological Studies at Prescott College, Prescott, Arizona. The possibility that souvenir hunters may plunder the caves before archeologists can study them has prompted the National Geographic Society to sponsor a full-scale dig by Dr. Euler this summer.

Sunlight kindles a rainbow and ignites the Redwall opposite Nankoweap Mesa in Marble Canyon. Storerooms abandoned 800 years ago cling to canyon walls along this stretch. They were built by a people whom the Navajos call Anasazi, "the ancient ones," even though they were Johnny-come-latelies compared to the makers of the split-twig figurines. The Geographic expedition camps on the beach at bottom.

crevice into the second chamber by bracing backs and feet. Oval-shaped, it held a second pool (page 673). Beyond that was an arched doorway leading up again to a third chamber that had the mood of an ancient chapel. All three chambers were quiet, hushed, almost hallowed. We named the place Silver Grotto, a new treasure of Marble Canyon.

Into the Unknown—on a Shoestring

Orange flames of our fire licked against the night while Fran and Loie prepared supper. The aroma of canned corned beef and cabbage filled the air as I walked alongside the river and gazed across at the ghost of another campfire of a century ago.

Around it I imagined the members of Powell's band: Powell himself, the one-armed leader, chatting with his brother Walter, who had left part of his mind in a Confederate prison camp. The boys called him "Old Shady," from the lusty way he sang that Civil War ballad. Sullen Jack Sumner, a rawhide-tough hunter and trader, had served as Powell's guide in the Rockies the previous summer, and he had recruited four of the crew—Billy Hawkins, Bill Dunn, O. G. Howland, and Howland's younger brother Seneca.

Three more members had joined them in Wyoming. One was a young Englishman named Frank Goodman; after rapids claimed one of the boats on the Green River, he left the expedition, gladly forfeiting a chance for fame. The second was Andy Hall, a robust, high-spirited bullwhacker of 18.

The last was Sgt. George Y. Bradley. A loner, thoughtful, fair in his judgment, Bradley was a man of cool and constant courage. He so disliked "chasing Indians" around Fort Bridger, Wyoming, that he jumped at the chance to join Powell's party, and Powell had enough influence in Washington to obtain Bradley's discharge for that purpose.

Why were they there? Powell, in a last letter from Green River, explained, "The object is to make collections in geology, natural history, antiquities, and ethnology for the institutions assisting the work." He had $1,100 from the Illinois Industrial University (now the University of Illinois), and less than that from the Illinois Natural History Society, under whose auspices the expedition operated. The Chicago Academy of Sciences provided $100, and the Smithsonian Institution loaned some instruments. The rest had come out of Powell's own pocket, now nearly empty.





Granite-flanked Sockdolager Rapids, whose name means "knockout punch," lives up to its

He did have one more unofficial sponsor. Ulysses S. Grant, Powell's old commander, had arranged for him to draw free Army rations—or the cash equivalent—for 12 men. He took the cash, to pay his boatmen.

A shoestring expedition, with, as Powell wrote, a modest purpose "to add a mite to the great sum of human knowledge." All they had to do was what no man had tried before.

On August 9, 1869, they found Vaseys Paradise, where a clear waterfall gushes from the limestone 100 feet above the river. We also stopped to admire it. In the gentle rain of its spray, the slope is covered with ferns, poison ivy, and wild flowers. Powell, who named it for a botanist friend, described it as "a wall, set with a million brilliant gems."

Dour Jack Sumner, little given to esthetic musings, called it "a pretty show." Then he added, in Sumner style, "I would not advise anybody to go there to see it."

Powell's men would have been incredulous,



EKTACHROME BY WALTER MEAYERS EDWARDS © N.G.S.

reputation as it nearly engulfs men and raft. Powell narrowly escaped drowning here in 1869.

as indeed most archeologists were a short time ago, if someone had suggested that man had gone there to see it 3,000 to 4,000 years earlier. One of the prime mysteries of the Grand Canyon country is associated with caves in this vicinity.

Here, in 1933 and 1934, explorers found about two dozen strange figurines, each made from a single tapering willow branch, split lengthwise, with the ends wrapped back and around to form an animal (page 686).

Since then, other western sites have yielded figurines. In 1954 spelunkers Arthur L. Lange and Raymond deSaussure reported seeing such figurines in four Grand Canyon caves. They also made a grisly find. While exploring the dark reaches of a cave along Cremation Creek, their heads brushed something soft. Their upturned flashlights revealed a four-inch hank of human hair, wrapped in cord and dangling from two sticks. The purpose of the fetish remains unknown.



Grand Canyon and its conqueror

"To add a mite to the great sum of human knowledge." Such was Powell's goal when he and his crew pushed off into the unknown on May 24, 1869. Spurious reports that they had drowned soon made headlines across the country. Powell later wrote, after perusing his obituary notices, ". . . it was interesting and rather flattering to me to discover the high esteem in which I had been held . . . In my supposed death I had attained to a glory which I fear my continued life has not fully vindicated."

After 98 harrowing days, Powell and his party at last emerged from the Grand Canyon's grip and reached their destination at the mouth of the Virgin River. The intrepid explorer led a second expedition into the canyons in 1871-72, and returned to the Southwest several more times to study its geology

Dr. Douglas W. Schwartz, Director of the School of American Research at Santa Fe, New Mexico, made a study of the four figurine caves and obtained the first carbon-14 dates. They were shockers: Two specimens yielded dates of 1580 B.C. and 1150 B.C.—close to 2,000 years older than any other artifact then known from the Grand Canyon.

What forgotten people could have penetrated to the remote fastness of these canyon caves so many centuries ago? Thus far, nothing has been found to link the figurines with any historic culture.

Below Vaseys Paradise and the Redwall Cavern, Powell was impressed by "one great bed of marble, a thousand feet in thickness. In this, great numbers of caves are hollowed out, and carvings are seen, which suggest architectural forms, though on a scale so grand that architectural terms belittle them."

He was describing the Redwall formation, a limestone rampart that girds the river. Its castellated battlements seem to press against the sky. The caves Powell mentions are today called the Royal Arches and the Triple Alcoves—huge apses hewn out of the limestone by wind and water. Their shadowed interiors contain inner arches and columns and dark



and Indian cultures. In a rare 1873 photograph (inset above), the one-armed Powell—he lost his right forearm to a Confederate bullet in the Battle of Shiloh—poses with a Paiute Indian.

Cramming many other notable achievements into his life, Powell helped to establish—and later headed—both the U. S. Geological Survey and the Smithsonian Institution's Bureau of American Ethnology. He was one of 33 eminent men who in 1888 founded the National Geographic Society.

Staff artist L. K. Townsend constructed this unusual 4-by-5-foot model of the canyon area from plastic relief maps made by the U. S. Army Topographic Command. He then repainted the surface to show relief features clearly, and staff photographer Victor R. Boswell, Jr., took this picture.

recesses, the whole resembling the burial chambers of kings from a time of giants.

Indeed, from the Arches to the Alcoves, the river has a somber character. The walls lift 3,000 feet above black-stained rock and gnarled mesquite trees. Here the Colorado has collected drear mementos of tragedy.

In 1949 an experienced river-runner, 79-year-old Albert (Bert) Loper, was swept out of his boat in 24½-mile Rapids and never seen again. We passed the boat, its stern bashed in, resting under a mesquite tree. Beside President Harding Rapids, we left wild flowers at the rough grave where railroad surveyor Peter Hansbrough lies buried under a pile of stones with a large rock as his headstone.

There is another grave on this rocky slope, that of a Mormon youth drowned in 1951 in Glen Canyon. His body washed two-thirds of the way through Marble Canyon to come to rest here in this solemn, peaceful cemetery.

Ancient Ruins Huddle High on a Cliff

Sun-struck, regal, the basin of Nankoweap welcomed us with light and green trees and wide white beaches. As we ran the curving rapids, a boisterous toboggan ride down a mile of rushing waters, we were able to make

out ancient structures, high up where the talus slope meets the wall of the cliff.

It is a hard climb of 800 feet, more nearly vertical with each step, until the last 50 yards are a ledge-to-ledge struggle. At the top, tucked under the cliff, a series of small storerooms remains in near-perfect condition, even though no one has used them for 800 years.

Kenny and Mike Garrett squeezed next to me on the ledge, and we gazed out upon a nature so profligate with her wonders that it numbed the senses. Dark clouds had built up far south of us; lightning stabbed a faraway world; then a rainbow arched over the entire canyon, anchored to one rim (page 687).

"How did anybody ever make a living up here?" Kenny asked.

"They sold hot dogs to river-runners," Mike joked.

"They had to be mighty hungry," replied Kenny, looking back down that long slope.

Unsolved Mystery: Powell's Hieroglyphs

Powell had noted these and other ruins with great interest. In Glen Canyon he investigated an old dwelling with a kiva, the sacred underground room which the modern Pueblo Indians, like their ancestors, reserve for religious rites. At the Little Colorado his men found ruins, fragments of pottery, and hieroglyphs—which later investigators have searched for in vain.

The one-armed soldier-scientist made a shrewd and correct observation, that the ruins were those of "the people who inhabited this country anterior to the present Indian races." In later years, as founder and first head of the Smithsonian Institution's Bureau of American Ethnology, Powell would help to open the long-closed book of the history of our Indian tribes.

At Unkar Creek, downstream from Nankoweap's cliff structures, the river bends abruptly to the east and churns through rapids in the shadow of a 600-foot cliff. Opposite the cliff, beyond a wide beach piled high with driftwood, a gentle slope contains the ruins of an ancient Indian village. Here Dr. Schwartz and a crew of 20 stalwart students had spent the broiling days of June 1968 excavating dozens of sites.

On an earlier trip I had flown down to Unkar from the South Rim aboard a supply helicopter. We skimmed the top of the piñon forest for a few miles; there was no hint in the haze ahead that the great canyon was there.

"All set?" pilot Wayne Learn asked.

"Set for what?" I replied.

Then, suddenly, the world beneath us vanished, and we were plummeting through a colossal space between towering cliffs. Wayne had a broad grin on his face.



"Never lost a visitor yet!" A National Park Service mule named Harris reviews a tourist caravan wending up to the South Rim after a trek down Bright Angel Trail. The sure-footed, well-trained beasts move steadily with little prodding or rein-tugging.

"It's good every time," he said. "Going over that rim is good each and every time!"

Doug Schwartz greeted me as I stepped out into the blast-furnace heat. The temperature was 124 degrees on the sand near the river. They might as well have been digging in hell.

"The heat is bad enough, but it's the wind that gets us," Dr. Schwartz told me. "It blew the whole camp down as soon as we had set it up. Then we set it up again, and it blew down again."

The canyon reveals no trace of human habitation for almost 2,000 years following the makers of the mysterious twig figurines. Then, about A.D. 700, a new people arrived on the North Rim. Archeologists call them Anasazi, a Navajo word for "the ancient ones." Their history is beginning to emerge from dim nomadic beginnings in the western deserts, through a more settled stage when the people lived in round houses, through the Pueblo period—when they built huge cliff dwellings





Sunset-coppered buttes in the Grand Canyon lift snowy pinnacles to a cloud-heavy winter sky. Majestic Isis Temple looms in the foreground, and Buddha Temple rises beyond. To the left, jutting out from the barely visible North Rim, stands The Colonade.

Of the canyon's shifting moods and aspects, Powell wrote: "It has infinite variety, and no part is ever duplicated. Its colors, though many and complex at any instant, change with the ascending and declining sun; lights and shadows appear and vanish with the passing clouds, and the changing seasons mark their passage in changing colors. You cannot see the Grand Canyon in one view ... but if strength and courage are sufficient for the task, by a year's toil a concept of sublimity can be obtained never again to be equaled on the hither side of Paradise."

at places like Chaco Canyon, Mesa Verde, Canyon de Chelly, and Wetherill Mesa.* Today modern Pueblo tribes, such as the Hopi and the Zuni, struggle to continue their immemorial traditions in the midst of floods of tourists.

In this long period, the depths of Grand Canyon itself figure prominently in only one brief hour, between A.D. 900 and 1150. At that time the tide of Anasazi settlement swept down from the rims of the canyons of the Colorado into places like Nankoweap and Unkar.

"I'm beginning to look upon Unkar as a kind of Anasazi Appalachia," Dr. Schwartz said. "Three or four families, probably from the North Rim, came down here about A.D. 950 and built close to the river—more people than we had previously thought. Somehow

*See, in NATIONAL GEOGRAPHIC: "Solving the Riddles of Wetherill Mesa," by Douglas Osborne, and "20th-century Indians Preserve Customs of the Cliff Dwellers," by William Belknap, Jr., both February 1964; "Searching for Cliff Dwellers' Secrets," by Carroll A. Burroughs, November 1959; and "Ancient Cliff Dwellers of Mesa Verde," by Don Watson, September 1948.



KODACHROME BY WALTER MEAYERS EDWARDS © N.G.S.

they eked out a marginal existence. Then they left. We think a great outwash from a storm might have ruined their crops.

"After a hundred-year gap, a large group moved in and occupied the dunes and hillsides. Perhaps a change of climate caused them to move down here. There are more than 50 sites on this delta—storage rooms and granaries and houses and kivas. Then, by 1150, it was all over. I would say that two or three generations lived here over about 100 years and then vanished. There's a lot we don't know, and this is a hard place to find anything out. I think some answers can be found on the rim."*

Eight miles below Nankoweap, the Little Colorado merges with the Colorado. Up its narrow canyon, boxed by 3,400-foot skyscrapers, is the *sipapu*—the weird travertine dome where the Hopis believe their ancestors emerged from the underworld (pages 684-5).

Powell's party reached the silt-laden Little

*The National Geographic Society will support Dr. Schwartz's archeological field work on the North Rim during the summer of 1969.



Above a deepening sea of shadows, a sun-struck butte—The Battleship—rides at eternal anchor beyond Hopi Point. A beeline distance of less than 12 miles separates this popular tourist overlook from the North Rim, background, but motorists who want to reach the far side must



KODACHROME © NATIONAL GEOGRAPHIC SOCIETY

travel a circuitous route to Navajo Bridge and then back south again on the Kaibab Plateau—a drive of some 200 miles. Those with the time and fortitude ride mules on a two-day rim-to-rim excursion via the Kaibab Trail. The round trip may be made in minutes by plane or helicopter.



Colorado on August 10. They had run Marble Canyon in a week, but their store of provisions was dwindling. Sergeant Bradley complained to his diary, "We have had no meat for several days and not one sixth of a ration for more than a month. . . ." And ominously, "The men are uneasy and discontented and anxious to move on. If Major [Powell] does not do something soon I fear the consequences."

For all of that, Powell camped here for two days to fix his position. It was a crucial thing to know. By his reckoning, they were already as far south as the Mormon town of Callville, which meant that the Colorado had to turn west, through totally unexplored country.

With a sextant, Powell climbed the 2,000-foot cliff near the river and looked westward. There he could see "the edge of a great plateau, from which streams run down into the Colorado, and deep gulches in the escarpment which faces us, continued by cañons, ragged and flaring, and set with cliffs and towering crags, down to the river." It was, as Powell said, the "Great Unknown." On August 13 his boats entered it.

As we left the Little Colorado, we took note of one other ruin—a chilling one. Far up at the topmost corner of Chuar Butte, small mirrors seemed to be flashing in the sun as our raft moved.

"Hey, look up there!" Kenny Garrett said. "Somebody's signaling." He scanned the cliff with binoculars.

"That's the wreckage of an airplane," Bill Belknap said. "You're too young to remember it, Kenny."

The debris scattered above us is all that remains of what was at the time the worst disaster in the history of commercial aviation. On the morning of June 30, 1956, in a sky spotted with thunderheads, a DC-7 with 58 persons aboard and a Super Constellation carrying 70 people collided over the Grand Canyon. The planes plummeted down almost three miles to a greater unknown than Powell's. No one survived.

Granite Gorge Marks a New Beginning

When our rafts reached Unkar, Doug Schwartz and his archeologists, like the Indians, had gone. In a thrill-a-minute ride, we skirted the cliff through wild Unkar Creek Rapids. By evening, we made camp before the entrance to the awesome Granite Gorge.

On the rim above us we could make out the stone tower at Desert View. It was probably near there that the first Europeans to behold the Grand Canyon came through the piñon forest to the edge of the abyss.

They were a company of Spaniards seeking gold and heathen souls as a part of Coronado's

Pipe-toting chopper maneuvers through the canyon with its dangling cargo, a damaged piece of a nearly completed pipeline washed out by a freak 15-inch downpour. Now being rebuilt, the line will help carry water from Roaring Springs below the North Rim to thirsty tourist throngs at Grand Canyon Village. Until its completion, a limited supply of water reaches park headquarters and its environs from a pumping station at spring-fed Indian Gardens, 3,100 feet below the South Rim. Before construction of the pumping station in 1932, water had to be hauled to the canyon in railroad tank cars.



Pint-size rumble seat keeps Robert Goetjen, Jr., out of harm's way while his father aims binoculars from Mather Point. The Goetjens, from Grants Pass, Oregon, were among more than 2,000,000 visitors to Grand Canyon National Park in 1968.

expedition to find the fabled Seven Cities of Cibola in 1540. Their captain had a name like the ruffle of Castilian drums—Don García López de Cárdenas. He was searching for a great western river mentioned by the Hopi Indians; he found both it and the canyon it had carved.

For four days his soldiers felt their way along the rim and probed into the canyon. Scouts returned from one descent to report with awe that a spire of rock apparently no larger than a man when viewed from above was, in fact, higher than the tallest tower in Seville. Frustrated, Cárdenas turned away.

In a cold morning rain, we waited for higher water to float us over Hance Rapids.

I asked Bill Belknap, our resident expert on canyon lore, how the rapids got their name. "From Cap'n John Hance," he said, "probably the first white settler on the canyon rim, and one of the West's premier storytellers."

"You mean liars?"

"Never," Bill said. "For example, he used to tell about the time the canyon was so filled with heavy clouds that he started walking across on snowshoes. The clouds started to clear and he just made it to the top of Wotans Throne. It was two days before enough clouds showed up to enable him to get to the North Rim. The clouds were thinner, but so was he!"

Under the lowering sky, we pounded through Hance, a wide, tumultuous sweep of thrashing waves spiked with rocks.

Then we drifted into a V-shaped cleft of stark-black schist walls, slanting upward from an unknown depth of earth. It had the feel of a fortress, an inescapable prison of black rock, under a black sky, on the current of a black river. Blood-red piping edged the sleeves of the thrusting rocks. A thousand feet of this satanic stone rose straight up on either side, and far beyond it fiery-hued walls shone in the sun. We were at the bottom, in the very crack of doom.

Knockout Punch of the World

At Sockdolager Rapids some of the canyon's biggest waves roll in a roaring cadence between the walls of schist without missing a beat. Powell thought this was the wildest place he had ever seen—the Sockdolager, or knockout punch, of the world (pages 688-9).

"The waves were frightful beyond anything we have yet met," wrote Bradley, "and it seemed for a time that our chance to save the boats was very slim."

How different were our rafts—balloons of neoprene that could bend, twist, and wriggle through the rapids—from the four narrow-beamed wooden craft used by Powell.

His larger boats, the *Maid of the Cañon*, the *Kitty Clyde's Sister*, and the *No Name*,



Mushroom-shaped thunderhead, with a chilling resemblance to a nuclear blast, blooms above the distant North Rim beyond Mather Point. Because precipitation tends to increase with altitude, the 1,500-foot-higher North Rim receives considerably more rain and snowfall than the semiarid



South Rim. Fierce squalls occasionally howl down into the mile-deep Inner Gorge, but most storms never penetrate the chasm's deep interior, where temperatures 20° to 30° warmer than at the rims cause much of the rain to evaporate and nearly all snow to melt before touching bottom.

must have handled like logs. Despite stout watertight compartments fore and aft, the danger of such boats had become evident in Lodore Canyon, where the *No Name* was dashed onto a rock and broken in two. They were terrible to manhandle over boulders littering the canyon floor, and it was infuriatingly awkward to "line" them through rapids —ease them downstream with ropes from shore. Powell portaged and lined the rapids far more often than he ran them.

The major and Sumner went ahead in a lighter craft, the *Emma Dean*, 16 feet of pine with a dancing jackstaff flying the flag of the United States with its 37 stars. In the midst of Sockdolager, the small *Emma Dean* was swamped when a wave rolled right over her, but she somehow kept afloat. Then a whirlpool spun her around and she went into the lower rapids stern first. She came out of the run half-drowned but safe.

Hance, Sockdolager, and then Grapevine—this giant staircase of rapids ranks among the angriest and most dangerous anywhere.

Phantom Ranch—a Welcome Refuge

Powell decided that to run Grapevine would be suicide. So, "clinging to the side of the granite cliff," they began to work the boats through on long ropes. Darkness caught them halfway down. The exhausted men secured the boats and crawled onto the wall, where they found inches-wide ledges to stretch their backbones upon while they vainly sought sleep, "tucked around," said Bradley, "like eve-swallows."

Grapevine gave the *Green* a spin, too. A flailing rope bit into the valve of one of the pontoon sections and ripped it out as neatly as a cork from a wine bottle. The raft crumpled along its left side and was thrown out below the rapid wobbling badly.

Repairs made, we drifted toward the welcome beach at Phantom Ranch.

It was hard to realize, as we stretched out by our warm fire that evening, that two million people, during the course of a year, come to stand on the rims far above us. We could make out lights from Grand Canyon Village on the South Rim, ghostly will-o'-the-wisps floating high in the quiet darkness.

While the national park embraces 1,052 square miles, the few miles around Grand Canyon Village *are* the Grand Canyon for most visitors, partly because of the tourist facilities—though these are increasingly strained during the summer.

The world comes to look and to wonder, and to back away from the brink.

I had felt that strange fear the first time I stood at the rim near Hopi Point. The abyss opens at your feet. You stand a single step away from overpowering space, filled to the limit of vision with an eternity of aging, crumbling rock (pages 696-7). Far below, the river flashes at the bottom of time.

Life Zones Span a Continent

The mile-deep gorge of the Grand Canyon spans four of the major life zones of the North American Continent. Each 1,000-foot increase in elevation is equivalent to a 300-mile northward move. Thus the ravens that float with such maddening freedom from the bottom of the gorge to the top of the plateau pass through four life zones, comparable to walking from the arid deserts of Mexico to the cool green forests of southern Canada.

In the gorge itself, rainfall totals only 10 inches a year. More abundant rains reach the South Rim—16 inches in an average year—and a forest of piñon pine, Utah juniper, and sage covers the Coconino Plateau there. On the North Rim, 1,500 feet higher, precipitation averages 25 inches a year. The Canadian forest of spruce and fir and aspen is covered in most winters with 150 inches of snow—a deep blanket that has to be plowed through in May, when the bottom of the canyon is already feeling 70° to 80° F. temperatures.

To know the canyon for what it is, a man must walk down into it. Two trails, the Bright Angel and the Kaibab, snake along switchbacks from the South Rim and drop down, down, down to Phantom Ranch in the inner gorge. The park's famous mules wend down Bright Angel (pages 692-3).

The one man who has walked more miles of the canyon than any other must be Dr. Harvey Butchart. A slight man with muscles

Muddy cataract leaps from sky-high cliffs, fed by a rainstorm on the Coconino Plateau. The short-lived torrent roared down this side canyon and sent startled expedition members scurrying for safety. Because the upland terrain slopes southward, streams and runoff pour into the canyon from the north but tend to flow away from the south. Erosion has thus gnawed the North Rim an average of twice as far back from the river as the South Rim.





The living canyon

LIFE, though it often goes unnoticed amid the immensity of inanimate rock, takes myriad forms in the Grand Canyon. Four different zones, each with a characteristic climate, exist between the floor of the gorge and the plateau high above.

Sheila Smith (left), wife of expedition pilot Ron Smith, gingerly harvests the fruit of a prickly pear cactus at Shinumo Creek. An orange-tufted "velvet ant" (below), actually a wingless wasp, examines wet candy provided by the photographer.

A young park visitor (right) prepares to blow the dandelion-like seed head of a goatsbeard to smithereens. Blossoms of a fishhook cactus (below right) seem almost incandescent against a stone backdrop.



KODACHROMES BY WALTER MEAYERS EDWARDS © N.G.S.

like piano wire, Dr. Butchart headed the mathematics department at Northern Arizona University until his retirement in 1967. Each vacation he has tramped the canyon.

He was sitting in the living room of his comfortable home in Flagstaff when I first met him. Spread out on his lap were large maps of the canyon, marked with black lines.

"Each of those lines represents a hike I've made," he said. "I've hiked about 20 miles a day, about 45 days a year, for about 17 years. It comes out to about 15,000 miles."

Canyon Offers No Second Chance

I scanned the lines, traveling so smoothly and easily over the white paper, and tried to match them against what really was there—sheer cliffs, narrow ledges, plunging ravines.

"It's a violent environment," Dr. Butchart said. "In 1960, a Navajo from the reservation walked down the old Tanner Trail from Lipan Point and kept going until he fell over dead from dehydration. A Catholic priest and two boys went down near Moran Point the year before. They didn't carry enough water. One boy survived.

"You have to respect the canyon because there aren't any second chances out there. It's the lure of overcoming danger, and intellectual curiosity, that keep me at it."

Dr. Butchart can go for four days on a 24-pound pack, eating only dried fruit, cereal, and sardines. We planned better fare for lunch, and he rose from his chair and limped to the closet for his coat. He motioned to his ankle.

"A fool thing," he said. "It happened a few weeks ago near Elves Chasm. I made a jump," he indicated a span of about seven feet, "and sprained my ankle."

"Still hurt much?" I asked.

He smiled. "Only the embarrassment."

I kept that in mind a few days later when I hiked down the Kaibab Trail. I was not 10



KODACHROME © N.G.S.



feet below the rim when the entire perspective began to change. And once out from the first line of cliffs and through the Redwall, I stepped also out of time and space.

The canyon soars around you, and you walk on and on and on without a line of it changing, or your objective getting any closer. Your legs float you through an endless spectacle that seems to have neither beginning nor end. What startles, and then comforts you, is that you are absolutely alone, and absolutely in command of your own survival.

I was climbing down through two billion years of the history of our planet. My footprints stirred the dust of vanished deserts; my boots crunched the tiny skeletons of creatures that lived in seas long gone. It gives a man some measure of eternity.*

It is easy to say that shale is simply hardened mud, that sandstone is just sand grains cemented together, or that tiny sea creatures gave up their shells to make limestone. But to see towering 200-foot cliffs of sandstone surmounted by 650 feet of shale, topped by 700 feet of limestone and another 800 feet of sandstone and shale, and more above that—it gives one the eerie feeling of looking deep into the very ribs of our planet (foldout, pages 678-80).

Powell Returned to Seek New Answers

Canyon geologists are fond of the story of the cowboy who rode to the brink, looked down, and remarked to his horse, "By golly, something happened here!"

Powell dedicated many years of his life to finding out what did happen. In the early 1870's he returned to the canyon country with geological expeditions better equipped than his first; the maps they produced filled in white spaces in the United States atlas. The major was influential in establishing the U. S. Geological Survey, and became its second director. He was also one of the founders of the National Geographic Society.

Those honors and achievements were far in the future, however, when his tired band made their way to the beach at Bright Angel Creek, where Phantom Ranch, a picturesque glen of cottonwood trees and rustic wood-and-stone cabins, now stands. The major took a sad inventory: "We have now only musty flour sufficient for ten days, and a few dried apples. . . . We must make all haste possible."

The Craigheads had to leave us at Phantom Ranch, but the *Grand* and the *Green* went on, hastening after Powell.

Beyond the hostile waters of Hakatai and Walthenberg Rapids, the massive Redwall seems to step closer to the river. The Colorado swings south into a wide U-shaped bend, around Explorers Monument—a panorama of baking walls of such magnitude that our rafts seemed like tiny chips awash in the gutter of a Wall Street. In this stupendous landscape, the canyon has hidden away one of its delicate wonders.

We tied to the left bank and made our way across a rocky, stove-hot talus to the side of a small stream. Over great boulders, around a series of stepladdered pools, is Elves Chasm, where Royal Arch Creek finds its way to river level by way of a beautiful waterfall.

The fall plunges into a deep pool, and within moments John Evans was plunging with it. His roar of pure delight at the freshness and coolness of the water echoed in the small canyon. The water creates a microclimate

*See "Grand Canyon: Nature's Story of Creation," by Louis Schellbach, NATIONAL GEOGRAPHIC, May 1955.

of moist vegetation—maidenhair ferns cling to the stony walls, and brilliant monkey flowers, like red orchids, peer from a lush garden of greenery.

A shadow dimmed the canyon as we got back into the boats. "Looks like it's time for our daily thunderstorm," Mike said.

But this one was different. The sky turned blue-black as we drifted downstream, and the rain came washing through the air in vast translucent sheets. Then we saw a sight that drew us to the shore again for a closer look.

Flash Flood Plunges Into Space

Through a notch at the distant top of the southern Redwall, a gigantic muddy waterfall was cascading down, a fantastic feather of red water billowing out through a thousand feet of space (page 703).

The fall dropped down into a basin hidden from our view by a line of cliffs, from which a 300-foot spillway of sandstone led over broken stones to the river.

We walked toward it, half-blinded by the driving rain but still gazing in astonishment at the spectacle of that mighty fall.

"Where can all that water be going?" I asked Bill Belknap.

"Well, there's only one place it can come out," he said. As if on cue, an angry sea flared up at the top of the spillway ahead and exploded down the steps toward us.

"Run! Run!" yelled Ron Smith.

We leaped over boulders like bighorn sheep as the flash flood roared down the gully, grabbing at our heels before it whooshed down to the river and spilled a torrent of red mud into the brown stream.

"After a shower," wrote Bradley, "it is grand to see the cascades leap from the cliffs."

But how grand he did not say, and we had not imagined until we saw it.

The next day, in flooding sunlight that filled the vast gorge with warmth, we turned



Bit of Eden in a rocky wilderness. A hanging garden blooms in the spray from Deer Creek Falls. When the Colorado brims at full flow, the 125-foot-high cascade spills directly into it.

Taking a vertical stroll, John Evans rappels down a sheer cliff to explore a swirled-sandstone hideaway above Deer Creek Falls. Veteran of Antarctica's ice-glazed peaks, he kept his mountaineering skills in tune by such wall-walking excursions.





west with the river and entered a most majestic place. Conquistador Aisle seems designed for ceremonies of the gods. Its 4,000-foot walls march in procession on either side, adorned with huge bays. Its monumental rhythm, from river to rim, gives the awed traveler an impression of power beyond man's imagining.

But the Colorado exacts a price for such beauty, as it had from us in the throat of Crystal Rapids: water smashing aboard, the raft groaning as decks slip and ropes turn to iron from strain, a cavern of water opening before us as we veer away from the cliff and slip into the maw. The great wave hits us. With a crack like a rifle shot, Toppy Edwards' waterproof photographic rig—15 pounds of camera and case bolted to a heavy tripod (page 671)—snaps off and hurtles backward past his head like an artillery shell.

And alternately, for every hazard the canyon offers a reward—the relief of sun-warmed sand on water-wrinkled feet, the pristine world of polished stones and cleanly sculptured white sand bars, the chill splash of shade under a tamarisk tree, the skittering flight of bats as they pour like blown leaves from a high cave, chuckwallas and collared lizards scampering away from the crackle of a bright driftwood fire.

One night in particular will remain in my memory. We were camped on a beach below a big and rough rapid. John Evans was plinking his guitar and singing—"Roll, Riiiver!"—when a glow lighted the crests of the cliffs above us.

"What on earth is that?"

Then we realized it was moonlight, bathing the high world above us before it had penetrated our depths. We lay back on the sand and waited expectantly. In a few moments the first rays shot from the distant edge of the canyon like a searchlight. Then the huge orb rose slowly over the rim; we could actually see it move, and timed its ascent at less than two minutes to full view. It rode into a sky of diamond stars and cirrus clouds, flooding the canyon with a ghostly blue light.

As we watched in spellbound silence, a wild burro, from somewhere high up in the dark canyons, brayed and brayed—one of the loneliest sounds I have ever heard.

After that we began to see small herds of burros browsing on the talus slopes, eking out a living from the desert vegetation. At Specter Chasm, a black door cut into the cliff by a side stream, we encountered our first desert bighorn sheep, standing like a majestic trademark on the rim above us.

Cliff-honing Colorado flows 3,000 feet below Toroweap Overlook in Grand Canyon National Monument, a 310-square-mile domain that adjoins the national park on the west.



Shy eavesdropper, a wild burro keeps a safe distance from two-footed intruders. The canyon's many burros descend from forebears brought into the area by prospectors long ago.

The bighorn has lived in the canyon for many thousands of years, but the burro was introduced only recently, by prospectors in the last century or so. Naturalists call it an "exotic," an improbable word when applied to this long-eared, ambling animal.

In the competition between bighorn and burro for water holes and forage, the exotic is clearly winning and the native losing. The National Park Service, faced with a hard decision, has found it necessary to control the burros' numbers lest they starve out the mountain sheep altogether.

As we slipped ever downstream, we made one brief side trip that Powell did not—into Havasu Canyon by way of its almost hidden entrance. Havasu Creek has cut so narrow a

passage to the river that a man can stand in the middle and touch each side. Beyond is a spacious glade with green grass—real grass—and crystal-clear pools that bubble and gush between silver rocks under a canopy of leaves.

Up this side canyon eight miles, beyond huge and spectacular waterfalls, lies the verdant Shangri-La of 260 Havasupai Indians, where their tribe has lived for centuries.*

In 1776, more than two centuries after Cárdenas had discovered the Grand Canyon, a Spanish priest, Francisco Tomás Garcés, found his way into Havasu Canyon by "a very precipitous trail." He stayed for five days with the Havasupai, noting with amazement that the canyon was so deep that the sun did not become visible until ten in the morning.

In recent years the number of tourists seeking out this Eden has increased, despite the hardships of reaching the village, Supai, by a long horseback trek from the plateau.

Where Water Met a River of Fire

We had been in the canyon for 20 days when we reached Lava Falls Rapids, 180 miles from Lees Ferry. Here a cataclysmic event a million years ago dammed the Colorado. Erupting from a canyon to the north, a river of lava poured into the great gorge.

Worn and hungry as he was when he discovered the place, Powell was carried away by it. "What a conflict of water and fire there must have been here!" he wrote. "Just imagine a river of molten rock, running down into a river of melted snow. What a seething and boiling of the waters; what clouds of steam rolled into the heavens!"

Over the years, the Colorado has gnawed away the lava dam, and fallen boulders have created the river's most fearful rapids.

High above our camp at Lava Falls towered Toroweap Overlook on the North Rim. It is the only place on the canyon rims reachable by automobile where the visitor can look straight down on the river.

On the way to Lees Ferry, I had found my way to Toroweap down the 65 miles of dirt road from the end of the pavement near Fredonia (map, pages 690-91). I had also found the comfortable stone house of Ranger John Riffey, a spare, weathered man of wry humor who has patrolled this 200,000-acre district of virtual wilderness for 25 years.

"When I came here, I figured I'd do 10,000 acres a year, and have it all covered once before I go," he said. "But I still see something new every day—a sure sign of failing memory."

We drove down to the overlook. With my heart banging like a loose piston, I inched along a narrow shelf toward the edge and peered over into nearly 3,000 feet of blue space (page 708). At the bottom, the brown back of the Colorado River glinted in the sun; muted by distance, the thunder of its rapids sounded like a sustained violin note.

I dangled my feet over the edge and sat there, stunned by the scale of the scenery. It seemed to me I could throw a rock across the gorge; yet the opposite canyon wall was three-quarters of a mile away.

The rim at Toroweap seemed very far away as the *Grand* and the *Green* fought through spectacular Lava Falls and entered the canyon's little-known western portion.

Powell, at this point, was racing for his life. On August 25 the men lined the boats through Lava Falls. Bradley noted, "We commenced our last sack of flour tonight."

The following day their spirits lifted with a long run through the widening canyon. "A few days like this," Powell exulted, "and we are out of prison." Then they came, near noon on August 27, to Separation Canyon and its huge rapids. "To run it would be sure destruction," Powell noted glumly, though he later decided to make the attempt. "The spectacle is appalling to us. . . . There is discontent in camp. . . ." Bradley wrote. "I fear some of the party will take to the mountains. . . ."

Three Leave River—to Die on Land

The next day three of the men, the Howland brothers and Bill Dunn, refused to go on. They preferred to risk climbing out.

Powell's lead boat, the *Emma Dean*, was beached and abandoned, and the other two were lightened by leaving behind barometers, fossils, minerals, and ammunition. Bradley described how the depleted party "dashed out into the boiling tide with all the courage we could muster. We rowed with all our might until the billows became too large to do anything but hold on . . . and by good fortune both boats came out at the bottom."

They waited to see if their comrades might now take the *Emma Dean* and run the rapid. But the three had shouldered their guns and gone—walking up what has been called, ever since, Separation Canyon.

*See "Land of the Havasupai," by Jack Breed, National Geographic, May 1948.







Going . . . going . . . gone—but only temporarily. Dauntless John Evans rides a wild stretch by aiming the Sportyak's stern downstream and rowing against the current to keep control (top). Despite his efforts, a thrashing breaker (center) overpowers the tiny craft and flips it upside down. Seconds later, John managed to right the upturned boat, clamber back aboard, and finish his watery toboggan ride.



Shadow and substance mingle in ghostly silhouette beyond Lipan Point as the sun

Separation is not a "good out," as old canyon hands put it, though it looks like one. From our camp at the riffle—the rapid is now drowned under water backed up by Hoover Dam—I walked up the canyon, and the illusion is one of a wide boulevard between distant buttes glowing rust and gold in the sun. It invites the traveler, weary of his canyon prison, but leads into many blind canyons.

Nevertheless, the Howlands and Dunn puzzled their way out. At the top, as Powell heard the next year from a Mormon scout, they met a band of Shivwits Indians, who fed them. The next day they went on. No sooner had they gone than a messenger arrived, telling the Indians that a small band of prospectors had killed a squaw. The Shivwits naturally assumed that Powell's men were the guilty ones. They tracked them to a water hole, where the men had made camp, and "filled them full of arrows."

On Sunday, August 29, 1869, Powell's remaining boats covered 42½ miles through country improving all the way. And the following day, at noon, they were out.

Ten men and four boats had set out from Green River, Wyoming, 1,000 miles and 98 days before. Now two boats and six men—the Powell brothers, Bradley, Sumner, Hall, and Hawkins—emerged from the unknown.



completes another passage over Grand Canyon and withdraws in mute splendor.

They came upon a party of Mormons, three men and a boy, hauling a seine at the mouth of the Virgin River. They were only 20 miles from the town of Callville. Their long, dangerous ordeal was over.

Gateway to the Outside World

"Our joy," wrote Powell, "is almost ecstasy." Bradley's last sentence was, "I wrote a line ... to assure Mother I was all right, but I was so intoxicated with joy at getting through ... I don't know what I wrote."

We felt some of that same release. The Grand Wash Cliffs opened their portals to the west and the blue sky widened as the *Grand* and the *Green*, mud-caked and much used, entered the choppy sea of Lake Mead. Yellow wild flowers spilled down a brown hill, and a fresh wind turned back the leaves of trees.

"Well, we made it all in one piece," Ron said. He spoke for all of us, but, strangely, we also had a touch of regret. We looked back at the Grand Wash Cliffs, the canyon's western gateway, and Mike Garrett said, "Maybe we'll do it again someday."

That is what we were all thinking. That lonely, lost, beautiful world at the bottom of the canyon had cast its spell. I would always hear a canyon wren singing somewhere in my memory. THE END



Forsaking the sea, a grunion slips ashore at midnight on a California beach.

Grunion

THE FISH THAT SPAWNS ON LAND

By CLARENCE P. IDYLL, Ph.D.

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Illustrations by National Geographic Photographer ROBERT F. SISSON

FIRES FLICKERED along the dark shore, silhouetting dozens of people on a warm June night at Cabrillo Beach in San Pedro, California.

Picnickers spread out upon the sand; transistor radios blared; children romped amid what seemed to be a beach party. Yet the exuberance was tempered with an air of expectation, for all of us were there to witness a remarkable spectacle: a run of grunion, the fantastic fish that comes ashore to spawn.

Despite the crowd around me, relatively few people ever see the grunion's astounding performance, for it occurs only in two



Boring tailfirst into the sand, she buries her eggs two to three inches deep.

areas in the world. The more common species, *Leuresthes tenuis,* dwells solely along the Pacific coast, from north of California's Point Conception to beyond Punta Abreojos in Baja California. A close relative with similar habits, *Leuresthes sardina,* frequents the northern Gulf of California. The gulf grunion may breed on the beach either by day or by night, but its Pacific cousin is strictly a nighttime spawner (map, page 719).

Spawning Time Synchronized With Tides

These small fish—adults are six to eight inches long—must time their landing so that they come ashore just after peak tides have begun to ebb. Only in that brief period can eggs be laid in the sand where the tide will not disturb them until hatching time about 10 days later. During the spawning season, the highest tides on the Pacific coast occur at night, twice a month; those on the gulf come sometimes in daylight, sometimes at night. The grunion have simply adapted to the local situation.

Picturesque legends about grunion behavior abound. It is claimed they are most likely to come in with waves that curl to the left. Or on the ninth—or seventh, or twelfth—wave. Another story has it that the grunion horde sends scouts to the beach to reconnoiter.



"The grunion are running!" Young and old scramble for the slithering spawners. Law permits


KODACHROME © NATIONAL GEOGRAPHIC SOCIETY

harvest of the tasty smeltlike fish only with the bare hands, and not at all in April or May.



Dance of motherhood: A female grunion shimmies tailfirst into the wet sand. Within 30 seconds she deposits between 1,000 and 3,000 eggs and returns to the water.



Male partner soaks the sand with milt, fertilizing the eggs (opposite) as they are laid. As many as 10 males may simultaneously join her in spawning.



With a tail-slapping burst, the female leaves her nest to ride the surf back to sea. She may come ashore to spawn as often as eight times during spring and summer.

My friend Lucius Smith, night watchman at the Cabrillo Beach Marine Museum, warned me against disturbing the few advance fish that usually signal the start of a run.

"Don't shine your light on them," he exhorted. "They might tell the others."

Lights do seem to make the grunion nervous, at least until the spawning frenzy hits them. The jarring of sand by running feet is even more likely to make the fish head back to sea.

The tide passed the full. Now was the time—unless the commotion of the crowd had sent the skittish fish to a more secluded spot. Or perhaps this just wasn't their night for Cabrillo. Although man and his tide tables can predict with good accuracy when grunion will appear, absolute precision is not possible.

The smooth wet slope of sand threw up a blurred reflection of distant lights. Then, like a magician's cloth being snatched from a table, the water was whisked away by a retreating wave, leaving the sand littered with dark little knobs of writhing fish. Our wait was over, the grunion were running!

I crouched amid hordes of these blue-and-silver fish as they cavorted in their highly stylized mating dance—if not on dry land, certainly well out of the water. They had allowed themselves to be flung high up on the beach by an incoming wave. Then, swimming against its ebb, they had purposely stranded themselves on shore.

I watched a female fish drill herself backward into the semifluid sand with side-to-side jerking motions of her body. In perhaps 10 seconds she had buried herself to her pectoral fins (upper left and pages 714-15). This activity excited the males, and quickly several of them flopped over to lie on the surface of the sand, curving their bodies around the female.

The agitated digging of the female now changed to a slow back-and-forth movement of her head. This is the time eggs are laid, 1,000 to 3,000 pinkish spheres to each nest. Simultaneously the males—commonly two or three but sometimes eight or ten attending each female—emit their milt, which sinks into the sand to fertilize the eggs (left center).

Suddenly the activity of the female increased again as she swung her body vigorously back and forth to free herself from the sand. Having wrenched herself loose, she wriggled toward the water (lower left). A

friendly wave arrived about this time and taxied her back into the sea. The entire incredible performance had lasted about 30 seconds.

Many thousands of grunion came and went that night on Cabrillo Beach. Happily, parenthood would not necessarily end their life cycle as it does that of the Pacific salmon, which dies after spawning.* Back in the water, grunion usually remain close to their normal breeding grounds until tides and some inner signal tell them it's time to go ashore again.

Careful studies, including tagging, show that the same female fish may spawn up to eight times in a season, beginning a year after her birth and continuing throughout the rest of her normal two- or three-year life span. Males may come ashore oftener than that, and there are usually far more males than females on the beach at any given time.

Eggs Buried Beyond Harm's Reach

A new generation of grunion lay only two or three inches beneath my feet. Every now and then the receding edge of a wave gently heaped more sand upon the burrows. Eventually the eggs could be buried as deep as 16 inches, protected from sun, storm, and the probing beaks of birds.

Bedded in the warm, moist beach, the embryos develop rapidly from a single cell into a tiny fish with a big head and prominent eyes, a long tail (next pages), and a pendant yolk sac. The baby grunion are ready to hatch in about 10 days. But they will not emerge from the eggs until high tides return to gouge them out. When sea water immerses the eggs and shakes them in the roiling sand, they hatch in two or three minutes. Once they pop from the egg cases, the fry swim with a receding wave into the ocean, where they are able at once to fend for themselves.

The timing of the spawning and the development of the eggs in relation to the tides is remarkably precise. Grunion usually wait to spawn until the night after the highest tide and the following two or three nights. Eggs deposited on nights before the highest tides would be washed out of the sand long before they had developed far enough to hatch. If they were spawned on the night of the very highest tide, the next series of high tides might not reach them.

Occasionally eggs do get marooned when the next peak tide is not quite high enough. In such cases the eggs simply do not hatch until the next series of tides sets them free.

*See "The Incredible Salmon," also by Dr. Idyll, NATIONAL GEOGRAPHIC, August 1968.



Beach nursery hides grunion eggs, each 1/14 of an inch across. The fish spawn during the ebb of twice-monthly peak tides. Thus eggs develop undisturbed by the surf until the next high tide, when they hatch.

Tuned to the tide, *Leuresthes tenuis* comes ashore only after dark. A Gulf of California relative, *Leuresthes sardina*, spawns either by day or by night.



If they miss that series also, they will die.

Crouching at the edge of the water to get the best possible look at the grunion, I had the seat of my pants doused by incoming waves. So, wet anyway, I waded into the surf to see what was happening there.

Grunion darted around everywhere, tracing paths of cold and ghostly fire. The night was dark, and they would have been completely hidden but for the luminescence their movement caused. Wherever the fish twisted and turned, their motion stimulated millions, perhaps billions, of microscopic one-celled organisms—dinoflagellates—momentarily to turn on their tiny flares.*

I had come to Cabrillo as a biologist and observer; many had come simply to watch, still others to catch fish. When grunion run in March, June, July, and August, fishermen with a California license and children under 16 may catch them in unlimited numbers—but only, the law specifies, with bare hands (pages 716-17). None may be taken in April and May, the height of the spawning season. When scaled, cleaned, rolled in flour and cracker crumbs, and deep-fried, these little members of the silversides family (Atherinidae) have a delicate, savory flavor.

Elusive as Soap Dropped in a Shower

During open season the antics of fishermen are as much fun to watch as the grunion. Beached fish are often easy prey, and the egg-laying females are especially vulnerable when imbedded in the sand. But sometimes a grasped grunion can squirt out of the hand like soap in a shower bath and can be as hard to retrieve.

One of the least effective yet most popular techniques is to stand in the surf and wait until the grunion start sweeping by. The eager fisherman follows at full speed, diving headlong for the nearest fish as it hits the shore. He usually ends up sprawled in the wet sand while the fish wiggles out of reach. In the melee many a bare foot is grabbed in error.

Those who get close enough might hear the sound the female fish is reported to make while spawning. Bob Sisson, who took the pictures on these pages, confirms that he has heard it: a noise like the squeak of a mouse, but lower in pitch. The name "grunion" is believed to derive from the Spanish word *gruñón*, which means "grunter."

Despite the frantic grunion gathering on

*A dramatic example of such marine bioluminescence was described by staff naturalist Paul A. Zahl in "Sailing a Sea of Fire," NATIONAL GEOGRAPHIC, July 1960.



ALL THREE PICTURES [illegible] TIMES LIFE-SIZE

Embryo glistens in a six-day-old egg. Two eyes bulge like tiny black beads. The tail curls around the food supply—the round yolk and adjacent oil bubbles.



KODACHROMES © N.G.S.

Flipping to freedom: A grunion fry uncoils like a spring as the thin egg case breaks. Eggs mature in about 10 days, hatching when an incoming tide exposes them and agitates the sand.

Instant fish. Once free of their egg cases, these quarter-inch fry swim directly into the surf. A fourth embryo still curls inside its egg. The hatchlings will grow to six inches or more as adults.





land, some accidental capture at sea by commercial fishermen, and severe pollution on many spawning beaches, the Pacific coast species appears in no immediate danger of depletion. Strangely but fortunately, most birds that relish anchovies and sardines, so similar in size, show much less interest in grunion. Winged predators usually pass up even the fish that spawn in the daytime on Gulf of California shores.

Hatchlings Emerge After a Shake-up

Although most grunion-watchers see only spawning fish, it is also possible at Cabrillo to observe the hatching of the young—and without a two-week wait. Every summer day, Director John Olguin of the City of Los Angeles's Cabrillo Beach Marine Museum spellbinds scores of children with a do-it-yourself demonstration of the grunion's hatching habits. I watched one of these oceanside sessions.

John designated some children as Waves and gave each of them a jar containing a teaspoonful of moist sand and grunion eggs he had dug up a fortnight earlier (opposite).

"You are the Tides," he instructed another group. "It's up to you to pour a little sea water into each jar. Now, everyone count to one hundred while the Waves shake the jars."

As the children counted loudly and the Waves shook their miniature aquariums, we all watched with rapt attention. By the time the count reached the sixties, the first eggs had begun to pop, and soon tiny explosions were occurring in each jar as baby grunion burst from their prisons (pages 720-21).

After the excitement of the hatch was over, John instructed the Waves to deliver the silvery babies to the sea.

"They'll be back next year to spawn," he assured them.

The wanderings of the Pacific grunion are not fully known, but apparently they do not move far from shore or much below depths of 40 to 60 feet. They grow to five inches in their first year and are then ready to spawn. Mature



Dance of the grunion is stepped off by John Olguin, Director of the Cabrillo Beach Marine Museum. Each year he shows 70,000 California school children how the little fish come ashore to spawn. The Spanish word *gruñón*, meaning "grunter," may give the species its name, since females have been heard to squeak while spawning. The scraped line marks the last high tide. Just seaward of the line, Olguin dug up eggs laid during the night's spawning to show the youngsters.

"Look, I'm a mother!" cries a schoolgirl as tiny fry begin springing from matured eggs kept in moist sand since the last high tide. The girls added sea water, then swirled the jar, imitating wave action. Before they could count to a hundred, they saw grunion hatching. After the demonstration, hatchlings were freed in the surf so they could return next year to spawn.



males seldom exceed six inches in length; the females may be slightly larger.

The first detective work on the grunion's remarkable life story was done more than 50 years ago by the late Dr. William F. Thompson, then at the California State Fisheries Laboratory. My interest in these amazing little fish began in 1941, when Dr. Thompson was Director of the School of Fisheries at the University of Washington in Seattle and I was one of his graduate students.

Mystery Still Surrounds Migrations

Since then Dr. Boyd Walker of the University of California at Los Angeles and other biologists have worked diligently on the life history of the grunion. But scientists still are puzzled by the astonishing ability of these fish to present themselves on the beach at precisely the right time for maximum survival of their young.

I wonder how those fish at Cabrillo knew the tide that night was just past its maximum peak for the lunar cycle. What instinct told them that taking their brief shore leave just then would safeguard their eggs from the surf during the 10-day incubation period to follow? How did they sense that the rising tide would release the eggs only after they had reached ripeness?

It is reasonable to suppose that the fish somehow have the ability to construct their own tide tables. Perhaps they do it by measuring gravitational forces that produce high tides, by detecting variations in water pressure as the tide rises, by noting cycles of light intensity or some other variable. It is likely that the grunion owes its punctuality to a highly accurate "internal clock," which somehow sounds the "all-ashore" signal at exactly the right moment.

And as long as the grunion's clock continues to work, it will summon spectators as well to the warm California beaches to observe this unique phenomenon, the fish that comes ashore to spawn. THE END

Abu Simbel's Ancient Temples Reborn

Article and photographs by
GEORG GERSTER, Ph.D.

FROM ALOFT, the two enormous pits that yawned in the cliffs of Abu Simbel looked like gaps left by the extraction of giant teeth. As my plane wheeled above Lake Nasser on a shimmeringly hot day last November, I felt an eerie sense of loss. It was hard to believe that there, scarcely four years ago, had stood those wonders of the world, the two colossal temples of the god-king Ramesses II, shaped from the living rock 13 centuries before Christ.

Now, I noted, even the pits were disappearing. The Nile's waters were rising in them, and a few lonely fishermen rowed over newly created depths, searching for catfish in precincts that had once been the scene of splendid ceremonies and processions.

But when I turned my gaze to the plateau above, the sadness that had touched me vanished. There, as if by some gigantic feat of legerdemain, stood Ramesses' 3,200-year-old shrines, reborn, complete even to the cliffs surrounding them (page 727). I had made many visits to Abu Simbel while the temples were being moved, and so I had seen the machinery behind this magic, but, far from disillusioning me, it only increased my awe.

The dismantling and reassembly of Ramesses' ancient temples ranks as the most spectacular moving job ever achieved by man. It began on November 16,



Immortality once again assured: Three colossal statues of god-king Ramesses II gaze serenely across Lake Nasser after one of the most dramatic rescues in history. Threatened by the Nile's waters rising behind Sadd el Aali—the Aswan High Dam—two 3,200-year-old rock temples were cut into 1,050 blocks and reassembled on higher ground. Here restorers in safety harnesses remove gauze bandages that protected delicate edges from damage while the cuts were being made.

KODACHROME © N.G.S.



1963, when the United Arab Republic signed a contract with Joint Venture Abu Simbel, a consortium of construction companies, to rescue the shrines from the rapidly rising waters of Lake Nasser behind the new Aswan High Dam. The task involved engineers from five countries and a then-estimated outlay of $36,000,000, supplied chiefly by the governments of Egypt and the United States, and including funds raised by UNESCO, the United Nations Educational, Scientific and Cultural Organization.

Because of their massive impressiveness, Ramesses' monuments were the first of the imperiled archeological treasures on the Nubian Nile to cause worldwide concern.* The Great Temple, celebrating the sun god Re-Harakhti and Ramesses himself as a living god, was built on a suitably godlike scale: The four colossi of the façade, representing the seated pharaoh, towered 67 feet. The Small Temple paid Ramesses' homage to Hathor, goddess of love, music, and the dance, and to his favorite consort, Queen Nefertari. But Ramesses made it quite clear who was the boss in the family: Nefertari was granted only two statues on the façade, a mere 33 feet high even though standing, each flanked by two statues of Ramesses (pages 736-7).

Raising the huge sum needed to move these temples took so long that they were the last of the threatened monuments above the High Dam to be moved. The project became a neck-and-neck race against a man-made deluge.

Giant Jigsaw Puzzle Has 1,050 Pieces

The first step in the salvage plan, conceived by the Swedish consulting engineering firm of VBB—Vattenbyggnadsbyrån—was to remove hundreds of thousands of tons of the rock surrounding the temples. The two monuments would then be cut into 1,050 pieces of as much as 33 tons each. These would later be reassembled 690 feet from the old shoreline, above the highest level of the reservoir.

On May 21, 1965, I watched skilled stonecutters free the first block—a mere 11 tons—from the cliff. A derrick swung it high, a trailer cushioned with sand received it, and a

*See also "Threatened Treasures of the Nile," GEOGRAPHIC, October 1963, and "Saving the Ancient Temples at Abu Simbel," May 1966, both by Dr. Gerster.



Carved to last for eternity, says an inscription at Abu Simbel. The Great Temple, far left, honors Ramesses II; the Small Temple, his wife, Nefertari.

Irving Johnson's ketch *Yankee* visited the site in 1964, just before salvage began. By May 1966, engineers had dug away 330,000 tons of cliff and had removed the sanctuaries, leaving gaping holes (lower).



Once again commanding the desolate Nubian frontier, Abu Simbel's relocated temples (right) stand more than 200 feet higher and 690 feet inland from the former shore. Light rims at water's edge identify the old sites. At its height Lake Nasser will climb the cliffs and lap a mere 200 feet from the base of the Great Temple's 67-foot-high colossi. A government hotel lies beyond; lack of tourists delays its opening.



tractor inched it gingerly to a storage yard. There it would wait more than two years until its turn came to be fitted into the giant jigsaw puzzle. Dismantling and reassembly overlapped, however; at no one time did all the blocks of the Great Temple lie in storage.

On January 4, 1966, the engineers set the first stone of the Great Temple in place at the new site. Some three weeks later, representatives of the United Arab Republic, UNESCO, and VBB met with Joint Venture to see the four gods of the Sanctuary—the innermost room—reinstalled (page 741). In accordance with the time-honored custom of depositing mementos in foundations, the engineers slipped beneath the seated gods some coins, a record of the ceremony, and copies of the Koran, of the latest issues of two Cairo daily newspapers, and of Egypt's National Charter.

Dismaying Message: Start Over Again!

Reassembly of the Small Temple proceeded less smoothly. In March of the same year, two months after workmen had set its first block in place, representatives of VBB and Joint Venture returned from a Cairo conference



KODACHROMES BY GEORG GERSTER © N.G.S.

Cutting up a king, an Italian craftsman saws where the fragile fingers of a colossus are least likely to suffer damage. Consulting with an archeologist, engineers selected the cutting points. Skilled artisans always tried for cleavages even narrower than the quarter-inch called for by the contracts.



Giant feet come to final rest. Workmen point out three brass surveyor's pegs essential to precise reassembly of the huge blocks. Before each section was cut and moved, surveyors implanted the markers and plotted their exact positions in relation to the rest of the structure. As the block was lowered for refitting, they again surveyed it, adjusting it to within less than a twelfth of an inch of its original location.

with startling news: All the Nefertari shrine already reassembled had to be torn down and rebuilt on a site seven feet higher.

André Ruiz, the French engineer who supervised work on the Small Temple, said: "At first I thought it was a joke—but from the look on the boss's face, it couldn't be. I went sky high—we had already reassembled an eighth of the temple blocks! And all for nothing!"

The agents of André's despair were Egypt's hydraulic engineers. They had decided to raise the maximum high-water mark of the lake by a meter (3.28 feet) to 600 feet above sea level. This adjustment added nine billion cubic yards to the reservoir and substantially increased Egypt's protection against devastating Nile floods. Unfortunately the hydraulic planners failed to give prompt notice to the rebuilders of Abu Simbel.

To complicate matters, the Egyptian Government decided that an extra margin of safety would be in order elsewhere too, and so decreed that the Small Temple—at a lower level than the Great Temple in both old and new sites—should be raised not just one meter but two. This decision, altering the relative





Promise of progress for the United Arab Republic spelled disaster for old Nubia. Three hundred miles long, Lake Nasser increases the nation's arable land by a third but inundates countless antiquities, some of which date from the Stone Age, as well as the homes of some 122,000 Nubian villagers in the U.A.R. and the Republic of the Sudan.

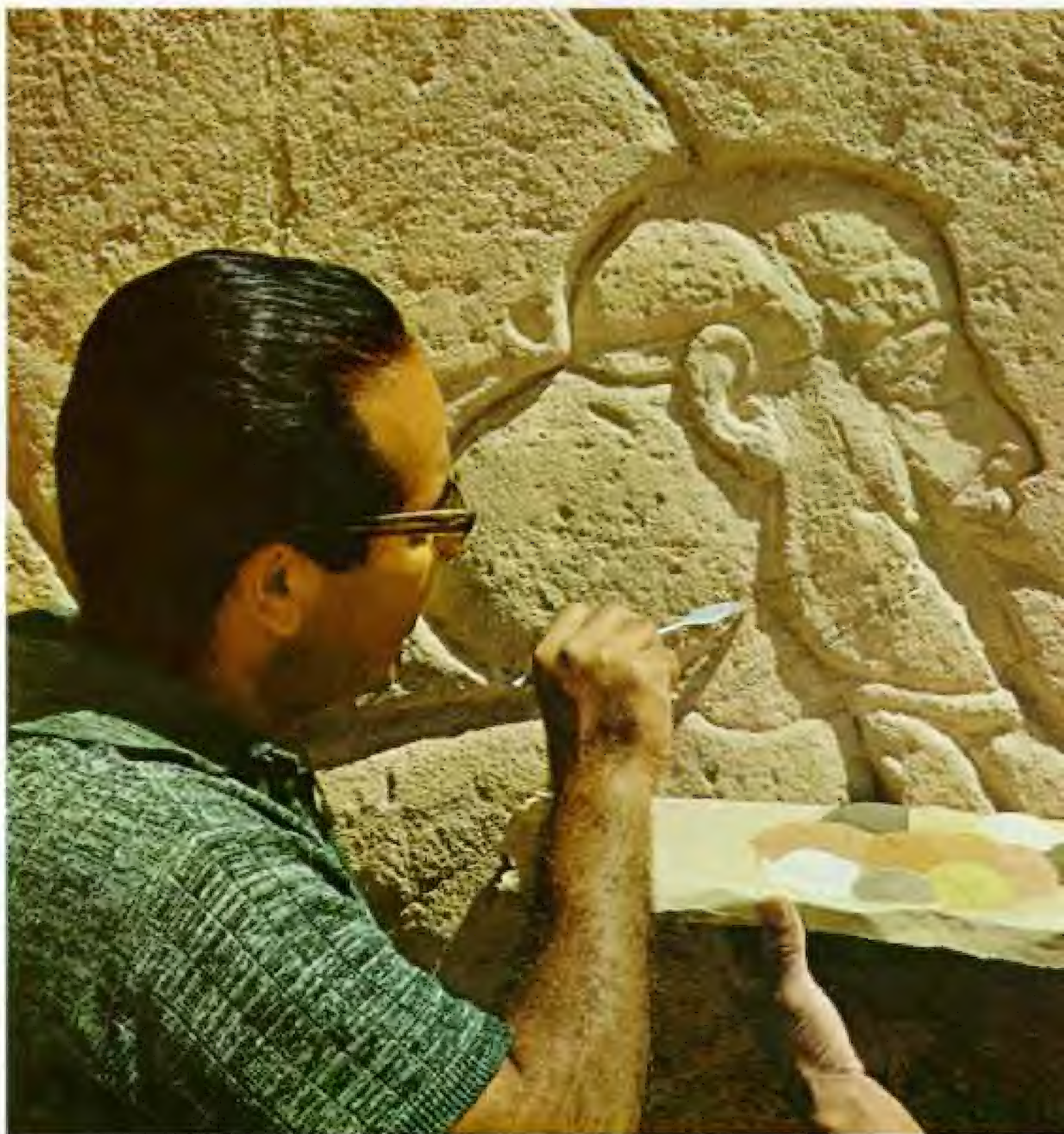
In 1960, the United Nations launched an appeal that drew contributions from dozens of nations and thousands of individuals. Abu Simbel was the largest of 19 monuments dismantled and saved. Plans for a final operation—the rescue of the temples of Philae, below the Aswan High Dam—are under way. The Sudan and the U.A.R. relocated the refugees in government-built settlements near Khashm el Girba and Kom Ombo.

In triumphal procession, the first of three colossal heads rides a trailer (below) from storage area to assembly site. Cushioned on sand, it inches along, with an entourage of Egyptian laborers and German, French, Swedish, Italian, and Egyptian engineers.

A derrick hooks onto steel lifting bars set in the block with epoxy resin and lowers the face into place (right). To prevent the 21-ton head from crushing the beard, salvagers earlier attached a 3½-ton concrete counterweight behind the chin. Dismantling and reassembly of the temples—a 4½-year effort—cost nearly $40,000,000.







Royal treatment for a pharaoh's captive: An Asian prisoner on the Great Temple entryway, bound to his companions by a looping rope, receives attention worthy of a king. Ali Bahgat, chief restorer for the project, matches colors from an artist's palette of ground sandstone to use in concealing joints between the blocks, such as the vertical one

vertical positions of the two shrines, further distressed the archeologists.

But, despite such frustrations, Joint Venture Abu Simbel had so far been an outstanding success. The engineers won their race against the rising waters of Lake Nasser with three months to spare.

On April 16, 1966, the last block from "down below" was put in storage, and dismantling was complete. The cofferdam—a temporary structure erected to keep the feet of the engineers as well as those of Ramesses dry during the cutting and dismantling operations—was no longer needed.

In late August a bulldozer cautiously started to open a breach for the lake. The driver, a Sudanese, confronted the rushing waters that would engulf the sacred site. The torrent swept around his vehicle but he courageously completed his task.

Prior to re-erection of the temples, all the blocks were fitted with steel anchor bars



KODACHROME © N.G.S.

above his head. Cracks from earlier days were left as found. Rameses ordered such reliefs to show prisoners he had taken during Asian and African campaigns.

which would be embedded securely in heavy concrete walls to be poured behind them (diagram, next page).

To help achieve exact repositioning of the roof blocks, the engineers used the same steel scaffolding that had supported them during dismantling. Now, as the blocks moved into place, surveyors struggled over every fraction of an inch.

The Joint Venture contract permitted a deviation of a tenth of an inch from the old positions, but the ambitious surveyors rarely tolerated that much. They checked and rechecked the precise placing of every block, using metal plates, wedges, and even a hydraulic jack to maneuver it before they unhooked it from the derrick.

Sometimes minute adjustments took hours. When the surveyors finally got a block into its correct position, they held it there with thin wooden slats and wedges, or with an underbedding of mortar, until anchoring concrete could be poured.

Smiling Face Rejoins Pharaoh's Body

The climax of the reassembly came on September 14, 1966, about three-fourths of the way through the restoration of the Great Temple. On that day I saw the first colossal pharaoh reunited with his smiling visage.

The ceremony had all the appearance of a triumphal procession. As a flatbed trailer moved the giant sandstone face at a snail's pace toward the new site, a visitor to the nearby settlements built for the people who rescued the temples would have searched in vain for a sign of human life. All of new Abu Simbel's 1,530 residents—engineers, workers, and their families—watched the procession along the route or clustered at the re-erection site, every one of them cheering.

When the pharaoh's face arrived before the Great Temple, a crane operator raised it carefully from its cushion of sand, using lifting bars that had been implanted before its removal from the original site. From behind, the face block had a new look. Fearful that it would topple forward as it was returned to the façade, the engineers had attached a permanent concrete counterweight to the back surface (page 731).

Slowly the 21-ton face and its curious concrete appendage rose above the spectators, hovered a moment over the two southernmost, partially rebuilt colossi, and finally came to rest on the figure immediately north of the temple entrance. There it took its place between the pharaoh's ears and above his ceremonial beard.

For me that day had a special personal meaning—it was the hundredth I had spent at Abu Simbel since my first visit in 1956. It very nearly became my last visit.

On the following morning, to photograph work on the Nefertari temple, I climbed up on a block that had not yet been reinstalled. Suddenly I felt it tilt, and I jumped off just in time to avoid being crushed under two tons of stone, stumbled over a small rock lying



PAINTING BY WILLIAM H. BOND, GEOGRAPHIC ART DIVISION; EKTACHROME (ABOVE) AND KODACHROME © N.G.S.

Showered by welders' sparks, workmen erect steel scaffolding in the concrete dome over the reconstructed Great Temple. Electricians used the framework to put in wires for lighting of the dome, the temple interior, and the façade.

Beneath a man-made mountain (below), an immense concrete dome protects the Great Temple from the tons of rocks piled up in imitation of Abu Simbel's original setting. Stepped wall behind the façade reinforces the colossi. Grid-like structure supports the ceiling blocks of the inner chambers. Pipe at rear draws fresh air into the shrine.



Modern engineering marvel matches the achievement of the ancients. Arching over the Great Temple, scaffolding holds forms for the concrete dome, poured in some 300 sections. With a span of 195 feet, the huge cap carries as much as 55 tons per square yard. Man in foreground guides a chunk of stone for the new cliff near Nefertari's temple.



nearby, and crashed to the ground. Luckily I suffered only bumps, bruises, torn clothes, and a smashed camera.

Of course I had to go over the details of the accident several times later. Each time the engineers to whom I was talking asked anxiously, "But what happened to the block?"

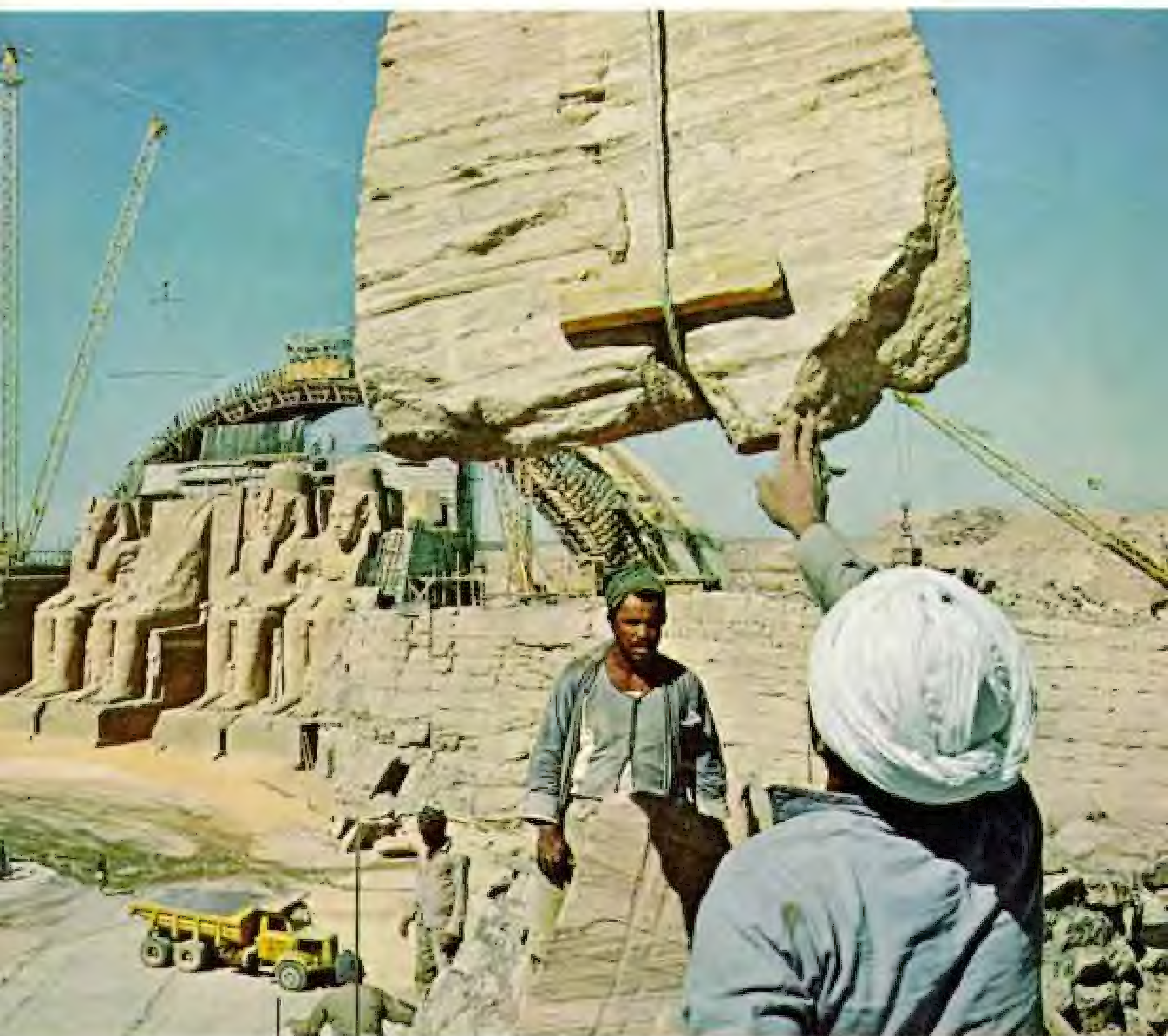
I was happy to see that their first concern was the welfare of the ancient stones. The one that almost finished me survived the incident undamaged.

By the end of 1966, much to the satisfaction of the engineers, the Nefertari temple stood in all its original splendor, though two months behind schedule. Three of the colossal guardians of the Great Temple gazed serenely out over Lake Nasser, while the upper body of the fourth, which had broken off probably in Ramesses' own day, reposed again at the statue's feet. In the autumn of 1967 the Great Temple was completed when the baboons on its cornice returned after a two-year absence to greet the rising sun (pages 742-3).

Shaft of Sunlight Marks an Anniversary

More than a year of work still lay ahead—reconstruction of the cliffs around the temples—but the core of the job was done. Once more, even as in Ramesses' time, the Great Temple stood ingeniously oriented to the sun. On or near October 20—the date of Ramesses' accession to power—and again about mid-February, the rays of the rising sun would strike 200 feet back into the Sanctuary, to illuminate the side-by-side statues of the god Amun and the god-king himself (page 741).

Ramesses smiled again, but what of the contemporary Nubians? Like the pharaoh,



"A mansion ... for the great royal wife Nefertari," proclaims a dedication in hieroglyphs on the façade of the Small Temple. Although created in Nefertari's honor, the shrine also glorifies her egocentric husband —twin statues of Ramesses flank each of hers. A concrete dome now protects the inner chambers, and restorers have camouflaged the cuts between blocks.



Auspicious dedication of the temples brings Ramesses and Nefertari to Abu Simbel in this artist's conception based on a ceremony depicted in a Great Temple bas relief. Outfitted with symbols of royalty, the pair leads a ritual procession. The pharaoh appears beardless, though he is sometimes portrayed with a false beard, a sign of authority. The queen carries sistrums, musical instruments sacred to the goddess Hathor.



they had had to flee the man-made flood and retreat to safe ground. I admired the skill and efficiency with which the engineers moved the great monuments of the past. I wondered whether the same efficiency applied when, instead of gods and grandeur, the fate of living men was at stake.

Between trips to Abu Simbel, I visited my Nubian friends in their new homes. The area affected by the dam included both Egyptian and Sudanese territory. Resettlement experts of the respective governments handled the problem in different ways, which resulted in a wide separation of the Nubians.

The Sudanese Nubians around Wadi Halfa were moved 560 miles to the Khashm el Girba irrigation project on the Atbara River near



PAINTING BY ROBERT W. NICHOLSON; EKTACHROME BY GEORG GERSTER © N.G.S.

the Sudanese-Ethiopian border (map, page 730)—or rather, most of them were moved. The rest took a solemn oath on the Koran not to be shoved off into an area they had not chosen for themselves. They objected to the dictatorial manner of the then-military government. Later, when a civilian government regained power, tension ebbed. Today 53,000 Nubians live near Khashm el Girba, where they plant cotton, wheat, peanuts, and sugar cane, and patronize *two* movie houses—an unheard-of luxury in old Nubia.

I chatted with a young farmer who was hand-picking Khashm el Girba's first cotton.

"The land is good. The movies are good. We are planting date palms."

It looks as if these Nubians are here to stay. Anyone willing to wait 15 years for date palms to bear a full crop intends to persevere even if the movies should turn sour.

Five thousand other Sudanese Nubians still remain in a new settlement near the old Wadi Halfa. The town is already flooded, but they are stubbornly waiting until a new harbor is built on Lake Nasser and shipping develops on the lake, bringing jobs for them with it.

New Villages Keep Their Old Names

As for the 64,000 Egyptian Nubians, they had no choice but to move. In their area the lake rose so high it left no shore worth fighting for. The Egyptian Government assigned them a crescent-shaped strip of land near Kom Ombo, about 30 miles north of Aswan, and

there built 43 new villages, named for the old villages in Nubia.

Resettlement came as a blow. A people that had enjoyed a 185-mile stretch along both sides of the Nile suddenly found themselves on a narrow, 140-square-mile, largely inland strip. This proved irritating to all concerned. Not only did the Nubians jostle one another, but they didn't get along well at first with the people native to the area, the Saidis.

The government-built houses near Kom Ombo were so small that only a few people could live under one roof; thus, in a single moment of crisis, a bulwark of Nubian society, the "greater family," was undermined. In old Nubia, houses had been spacious enough to accommodate a whole clan rather than just one immediate family.

Despair Gradually Turns to Hope

One Nubian friend of mine, though, faced an opposite problem. Abdel-Rahim Abba Yassid Garrar, a Moslem from the village of Tushka, has three wives. In old Nubia they had lived in three houses, each separated from the others by a day's donkey ride.

Winning the race with the rising lake: During the final stage of removal, in January 1966, all of the Great Temple has been dismantled except for some ceiling blocks of the Great Hall (left), here supported by felt-topped steel girders, and some of its walls



"It was heaven," my friend lamented with a wry smile. "Now it is hell. All my wives must live under one roof."

At first the Egyptian Nubians found their new life difficult and bitter. They fretted about their homes and their land. Most of it was not ready for cultivation, lacked irrigation pumps, and was too far from the river. Above all, the Nubians badly missed living on the banks of their beloved Nile.

Sickness took a heavy toll, especially among children and the aged. Even the Nubian cattle suffered. The Egyptian Government had temporarily quarantined the herds near Aswan, and many animals died there; of the survivors, a large number had to be slaughtered for lack of fodder. The monthly allowances that the government paid to ease the Nubians' transition, though adequate in some areas, barely sufficed in those regions where the Aswan construction boom had caused skyrocketing prices.

A spiritual virus seemed to sap even the people's innate artistic sense. In some villages the Nubians had begun to cover the stone walls of their narrow houses with Nile mud and to

and pillars. Trucks carry blocks up the winding road beside the cofferdam to storage areas. In mid-April (center), the last blocks leave the site; men and equipment depart. By September (right), Lake Nasser floods the cavities, but Abu Simbel's temples are safe.







paint traditional decorations on them. In the stately courtyards of their former homes, these murals had evoked much enthusiasm from travelers, but I found the new paintings without substance, without soul. The diligent attempt to carry on as if nothing had happened depressed me more than if I had found frank despair.

On later visits I saw conditions slowly improve. I found tiny plots of land luxuriantly green with grain sorghum, and I watched the Egyptian Nubians picking cotton, their white gold, for the first time.

For centuries these people have displayed a talent for adjustment. Deprived of their river, those who once lived by hauling passengers and cargoes across the Nile in their graceful, lateen-rigged feluccas now pursued their old vocation on land with donkey carts and rickety taxis.

Finally, the Nubians not only managed to adjust, they spearheaded progress. The last time I saw the *omda*—the headman—of Tushka, he was busily advising the village elders how to save the school. Because the year's enrollment was too low, the villagers feared the government would close it. They finally persuaded the neighboring Saidis, who until then had defied school-attendance regulations, to allow their children to be taught side by side with the little Nubians. The school was not closed.

As farmers, the transplanted Nubians can look to an assured future. "Soil texture and fertility are excellent, and drainage facilities are adequate," Hawaii-born Dr. Takumi Izuno told me as we toured the relocation area. A plant geneticist and consultant to the Aswan Agricultural Development Center of Kom Ombo, he was helping the Nubians experiment with traditional and new crops, improve animal husbandry, and adapt to modern agricultural methods and equipment.

As we drove through the dusty desert, past fields still somewhat scattered but growing well, he remarked thoughtfully, "What the Nubians need is time. They are eager to learn and are willing to work."

Landscaping Brings Up New Problems

At Abu Simbel, too, time was still needed. The last phase of the project, the landscaping, proved much more difficult than anticipated.

The original temples had been cut into the cliff face; their interiors were underground. At the new site, engineers planned to create artificial hills over the temples to imitate the original setting. Since the reassembled monuments could not bear the weight of these stony mounds, plans called for reinforced concrete domes to carry the load.

The Great Temple dome presented perplexing problems. A concrete structure of this height and span (90 by 195 feet) intended to carry such tremendous weight—as much as 55 tons per square yard—had never been built. Some specialists doubted whether it could be built at all. But in the end the engineers produced a technical masterpiece that is strong enough to sustain several times the maximum load on the dome (pages 734-5).

They did it by amalgamating about 300 concrete pieces into 34 huge arches. To prevent the concrete from drying too fast and crumbling in the heat, they cooled each segment as they poured it.

In designing the dome and supporting scaffolding, engineers used a computer,

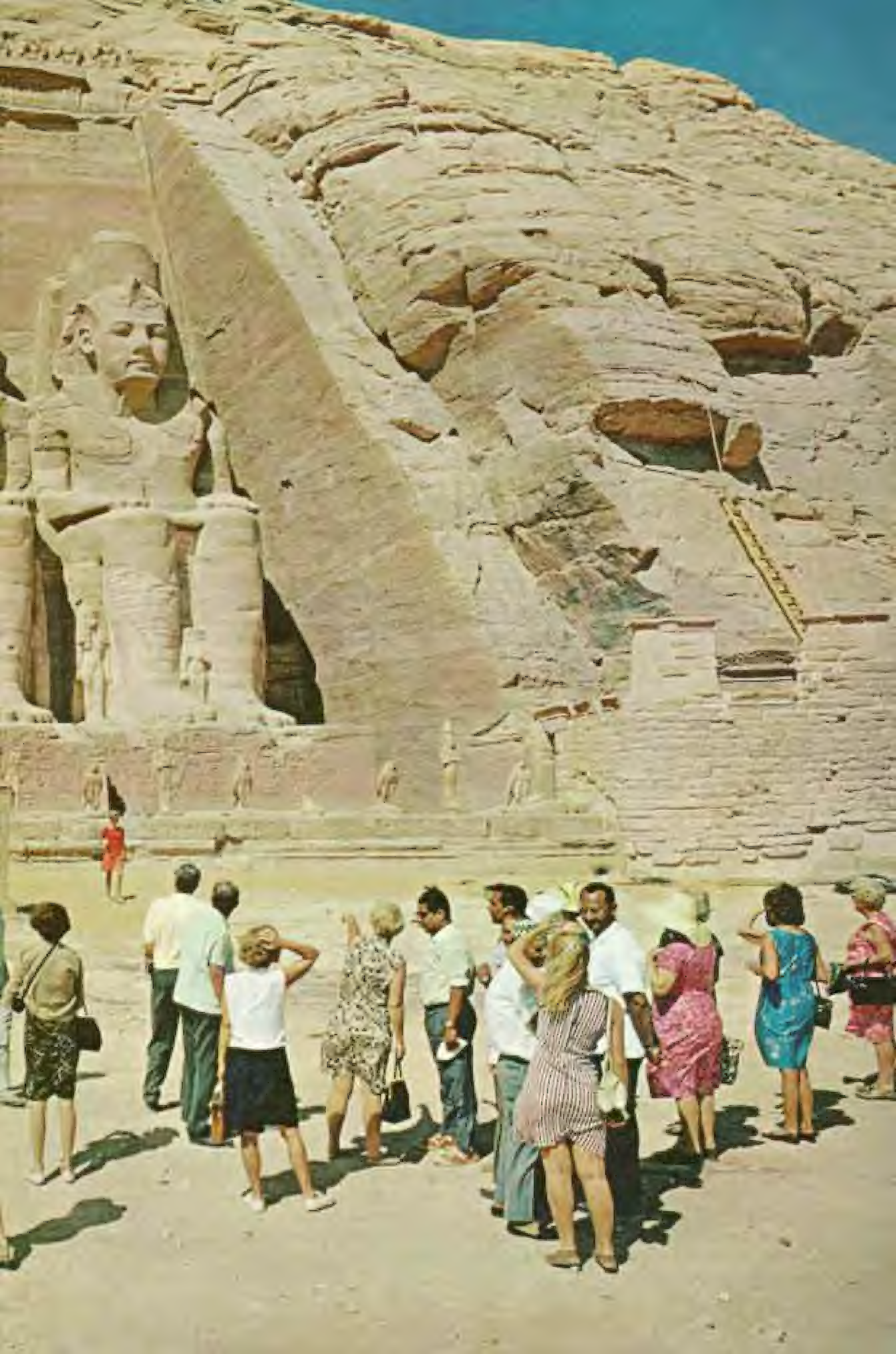


Today as for 32 centuries past, Ramesses communes with the holy sun in his reconstructed Great Temple, which retains its original alignment with the east. The light of morning daily visits his 30-foot statues in the Great Hall (left). And twice a year the rays penetrate 200 feet to the depths of the inner chamber (above) to bless a statue of the king dwelling in the company of the gods. Ramesses considered himself one of them. He sits between Re-Harakhti, the sun god, partially visible at right, and Amun, god of Thebes. Ptah, god of Memphis, at extreme left, dwells forever in gloom, just outside the reach of the rays.

[illegible] (OPPOSITE) AND KODACHROME © N.G.S.



DWARFED BY RAMESSES' MAGNIFICENCE, *visitors marvel at the reconstructed temple which preserves the pharaoh ever young and stalwart. Falcons, symbols of both the king and the sun god, stand guard at the base. Baboons on the cornice raise hands shoulder high to worship the eastern sun.*



for the interaction of forces among the 300 pieces was fantastically intricate. VBB believes that no other construction job ever required so extensive a computer program.

By the end of 1967, as the first three turbines began to run in the powerhouse of the Aswan High Dam, the domes over both temples were in place. A few days later they began to assume their burden of rock.

"Since such protective domes are designed to be at their strongest once the weight is actually resting on them, we might have made them thinner if only we'd been able to dump the rock fill from above," VBB's Karl-Ivar Jennerot told me. "From a helicopter, for instance," he quipped.

The only practical possibility, however, was to pile up the rock fill from ground level. As the rock pressed against the lower parts of the Great Temple dome, it actually moved the top of the dome upward one-fifth of an inch—an effect the engineers had allowed for.

Plans Made for Tomorrow's Tourists

In the reconstruction of the temples, visitors have not been forgotten—and the dome of the Great Temple may play an important part. The engineers have made room for electrical cables in the hidden joints between blocks so that the interior can be lighted and spotlights can illuminate the exterior of the temple. They have installed a ventilation system to circulate air within the chambers, remembering how unbearably sticky these often became at the original site. The engineer who told me this laughed bitterly.

"Abu Simbel will sink back into oblivion when we are gone, and once again it will be just as it was before—a place at the end of the world," he said.

All concerned hope that this pessimistic prophecy will not be borne out. However, tourist traffic shrank to a trickle after the Six Day War in the Middle East in June of 1967. The new hotel, with a splendid view of Lake Nasser, stands empty because of lack of business. In early 1968, the airline that inaugurated service between Abu Simbel and Aswan gave up after a few flights. But now business appears to be increasing—enough to fill two daily hydrofoils from Aswan.

Despite the lack of a large audience, the landscapers proceeded doggedly to beautify the new site. To imitate the original temple surroundings slavishly was out of the question. VBB planners had always admitted that the new location would be artificial, but just how artificial became clear only gradually.

The new hills are respectively 76 and 52 feet lower than the old cliffs, and that gives the temple façades and the rock that frames them an unexpected appearance. No one even considered raising the hills to the original height. Every additional yard would have cost $200,000, and the total bill for Abu Simbel's salvage had already exceeded the $36,000,000 budgeted by about 10 percent.

The restoration of the rock framing the temple façades left something to be desired. The planners realized too late that the quarried blocks used over much of the front of the hills were too small—just one square yard of surface each. Because of the many joints, the hills conveyed the impression of stone walls, and the construction workers derided their product as the Great Wall of China.

The question of what to do with the joints, not only on the exterior but also throughout the temples, hung in the air for a long time. Dr. Anwar Shoukry, resident archeologist at Abu Simbel, believed it would be most honorable not to fill them all the way to the surface, at least inside the temples. He felt it should be clear to future generations that Abu Simbel was a Humpty Dumpty successfully put back together again. But he yielded to the objection that erosion would endanger the surface edges of the blocks, and it was finally agreed to camouflage all traces of cutting (pages 732-3).

In the interiors and on the façades, six miles of joints were so carefully filled that even the most observant visitor can no longer find them. On the cliff faces around the façades, the filling of another 10 miles of joints has helped soften the visual effect.

Reborn Temples—Marvels of Two Eras

Though Abu Simbel will never again appear exactly as it did, a new dimension of wonder has been added. Sergio Frascarelli, one of the engineers of Joint Venture, summed it up for me:

"No one knows how many man-years it cost to carve these monuments out of the rock. But we know it took 4,000 man-years to remove them from the rock, raise them, and preserve them for posterity. And these 4,000 man-years have not only salvaged the temples—they have contributed something to them. The domes, for example. Abu Simbel was a wonder of ancient times. Now it is also a wonder of our own time."

NATIONAL GEOGRAPHIC SOCIETY

WASHINGTON, D. C.

Organized "for the increase and diffusion of geographic knowledge"

GILBERT HOVEY GROSVENOR
Editor, 1899-1954; President, 1920-1954
Chairman of the Board, 1954-1966

THE NATIONAL GEOGRAPHIC SOCIETY is chartered in Washington, D. C., in accordance with the laws of the United States, as a nonprofit scientific and educational organization for increasing and diffusing geographic knowledge and promoting research and exploration. Since 1890 the Society has supported 492 explorations and research projects, adding immeasurably to man's knowledge of earth, sea, and sky. It diffuses this knowledge through its monthly journal, NATIONAL GEOGRAPHIC; more than 24 million maps distributed each year; its books, globes, atlases, and filmstrips; 30 School Bulletins a year in color; information services to press, radio, and television; technical reports; exhibits from around the world in Explorers Hall; and a nationwide series of programs on television.

Articles and photographs of travel, natural history, and expeditions to far places are desired. For material used, generous remuneration is made.

COVER: Colossal face of Ramesses II is lowered into place during reassembly of the 3,200-year-old Egyptian temples at Abu Simbel (pages 730-31).

KODACHROME BY GEORG GERSTER © N.G.S.

NATIONAL GEOGRAPHIC MAGAZINE

The General Dual S·90 Sidewinder: the tire that fixes flats.

The Sidewinder seals punctures as it rolls. General's patented puncture protection is designed to keep you riding undisturbed, undelayed.

Count on having added protection against blowouts because the new Sidewinder uses four full plies of Nygen®—General Tire's own extra strength processed nylon cord.



Count on the long, safe mileage that comes with its deep treads of exclusive Duragen® rubber.

The Sidewinder: you may never change tires again.

There's more help: the assistance you get from the Sidewinder's remarkable Hi-Low Tread Design. The Sidewinder is built with an outside edge that is actually *higher* than the inside.

To make curves and corners easier.

To help with your stability and keep you in control of your car when you're traveling high-speed straightaways.

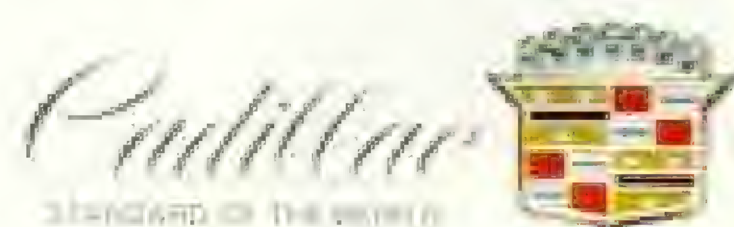
The General Dual S-90 Sidewinder. You may never pay more for a tire. But can you afford to pay less?



Goes a long way to make friends



The Fleetwood Eldorado represents the finest possible investment in personal motoring. Its front-wheel drive combines with the largest production V-8 engine in the world to produce an unequaled measure of driving satisfaction.





Stilt-borne beetle beats the heat

IN THE NAMIB DESERT of South-West Africa, one of the oldest and driest of all earth's wastelands, life has taken strange shapes to adapt to a torrid climate. The beetle below, for example, walks on stilt-like legs that keep its body high off scorching sands.

With the support of the National Geographic Society, Dr. Edward S. Ross (left), Curator of Entomology at the California Academy of Sciences in San Francisco, focuses on the Namib's amazing cast of characters for a future issue of the GEOGRAPHIC. Share it with friends by nominating them for membership on the form below.

Stenocara phalangium, almost 3 times life-size. PHOTOMACROGRAPH BY EDWARD S. ROSS © N.G.S.



Enter: The 360. From Polaroid.

The electronic flash boop-boops.



This remarkable all-electronic camera even sounds off the instant your picture is ready, to make sure it's perfectly developed.

You slide the electronic flash unit into place with a satisfying click and flip on a tiny switch.

Instantly, a light and a rising sound signal tell you the flash is building energy. A light starts flashing and the sound switches to a *boop...boop...*

You are now ready to shoot 40 flash pictures, without stopping once to put in a flashbulb.

As you focus, louvers in the flash unit automatically adjust to deliver the exact amount of light you need. You depress the shutter and zoing! the strobe releases a 1/1000th of a second burst of light, fast enough to freeze a juggling act or capture the wildest dancer at the party.

You pull the film packet out of the camera. Automatically, an electronic timer is activated and the timer light goes on. The instant the print is perfectly developed, the light goes out and the timer goes *beeeeep.*

Now: peel off your picture. Perfectly exposed. Perfectly developed. And all you did was aim and shoot!

Keep shooting. After you've taken 5 film packs (40 shots), you place the electronic strobe in its charger unit and plug it into the wall. It recharges itself automatically.

Sound sort of James Bond? The 360 is no fantasy. It's real and it's here, to give you more excitement than you ever imagined you could get from picture-taking.

You'll take wonderfully spontaneous pictures. No more albums full of wooden friends



As you focus, louvers adjust automatically to insure correct light intensity.

and relatives. You'll never have to ask your subjects to pose. The film is exposed only for that millisecond of light. If your

The electronic timer beeeeeeps.

hand jiggles, you don't have to worry. The pictures are always razor sharp.

You'll never have to use another flashbulb (so you'll never run out of them!). Let's say you're having a party. You take 40 pictures. One last shot? Plug in for 10 minutes and you can shoot another pack.



1/1000th of a second exposure makes possible spontaneous flash pictures.

Plug it in for an hour, it's fully recharged. When you're not using it, just keep the flash unit plugged in, like your electric toothbrush.

Best of all, The 360 gives you the freedom to shoot when the moment is right.

You'll get perfectly exposed shots, indoors or out. This remarkable strobe light is particularly kind to flesh tones. Outdoors, the sophisticated electric eye and electronic shutter system will read the light and set the exposure automatically.

You won't waste any more pictures because of poor timing. You set the timer correctly and let it worry.



No flashbulbs ever. Electronic flash shoots 40 pictures, recharges on house current.

One fascinating feature will give you an inkling of the ingenuity that went into this camera. In the timer, the shutter and the flash unit are circuits containing transistors, resistors, and other electronic components. Each would normally fill a space as large as a deck of cards. In The 360, they have been reduced to tiny chips of plastic-covered silicone less than 1/32 of an inch square, about the width of a pencil point.

This new Polaroid Land camera has a Zeiss Ikon range- and viewfinder. Triplet lens. Four film speed settings. Two exposure ranges for color, two for black-and-white. It can take Polaroid camera attachments for close-ups and portraits. It has a tripod socket. And instant pack-film loading.

This most distinguished of



Electronic circuits reduced from the size of a pack of cards to the size of a pencil point.

the new Countdown Cameras, the finest camera Polaroid has ever produced, is in the stores now.

See it and hear it.



The new 360. From Polaroid. The world's most self-sufficient camera.



"I've had a driver's license for 47 years. Yet I've never passed a driving test."

This woman is possibly the deadliest driver who ever set foot in a car.

Or perhaps she's the safest.

Nobody knows.

What's worse, nobody will know until she commits a couple of deadly acts.

You see, when she got her license, tests weren't required. And in her state, once you get a license, no matter how, you never again have to prove you can drive.

Never.

And hers isn't the only never never state. There are far too many just like hers.

States where some people may never have to prove they can drive. Or at best, only once. Even if that once was 20, 30, 40 or even 50 years ago. And even if the car they took the test in was a 45-horsepower job. And the speed limit was 45 miles per hour.

But now there are 400-horsepower cars racing about at speed limits up to 70 miles per hour.

On top of all that, people change too. And not always for the better.

So if you want our roads made safer, write to your local legislator and demand driving tests which really test, given often enough to weed out drivers who have gone bad.

Not everyone should drive.



The Continental Insurance Companies, the dial-a-claim companies.

Continental Insurance • Firemen's of Newark • Fidelity & Casualty • Commercial • Niagara • Seaboard F. & M. Buckeye Union • American Title • National-Ben Franklin Cos. • Boston Old Colony • Washington General
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Oldsmobile recreates a scene from the classic movies.

GM

Olds Vista-Cruiser: Keeps a sharp lookout with 11 windows.

It's easy to see why Olds value is way ahead of its price.

Take a look: Over 100 cubic feet for storage. 2- and 3-seat models—and all seats face forward. Tinted Vista-Roof. You can order a luggage rack for it. And a tailgate that drops or swings.

You'll see youngmobile thinking in its new styling, Rocket 350 V-8 engine, GM safety features, too. Get a new view on wagons—at your nearest Olds dealer's.

Escape from the ordinary.



United. The Hawaiian High Way.

One airline best flies you here – where the scene is as wild as the scenery. Where the thermometer is stuck at 78°. Where the people really love you. Where the lively switch on. Where the weary stretch out. That airline is United. We carry more people to Hawaii than any other line. We give you all sorts of tours and fares. Plus a credit card to charge everything. Talk it over with your Travel Agent. He'll arrange your whole trip. Then come fly with us to Hawaii. It's a great state to be in.



Let United put you in this happy state.

THE CLASSIC BEAUTY OF KREMENTZ JEWELRY is the result of imaginative artistry, enhanced by superb craftsmanship. And with its heavy OVERLAY of 14 Kt. GOLD, this finer jewelry has much of the wearing quality and all of the rich beauty of solid Karat Gold.

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Enjoy the unique pleasures of Japan. All the way round the world.

The cuisine is Continental, but you may enjoy trying chopsticks for the Japanese delicacies served first.

London. Hong Kong. Tokyo. Paris. Singapore. Wherever you're going around the world, we go, too. And we take you there in the nicest way. Come aboard one of our Jet Couriers in New York, San Francisco or Los Angeles and let us introduce you to a way of life you may have missed last time. Your kimono-clad hostess has been trained since childhood in the art of pleasing guests. She greets you with a refreshing *o-shibori* hot towel. A fragile cup of warmed *sake* is offered. And all the while you're relaxing in a brocaded lounge chair—surrounded by the subtle delights of Japan.

Whether you're rushing to a business appointment—or traveling for pleasure, Japan Air Lines brings a special bit of serenity to your trip. Ask your travel agent about us. Why be a passenger on some other airline when you can be our guest?



JAPAN AIR LINES

official airline for EXPO '70

What are you doing this weekend?



Why not visit a foreign country?

One you don't have to make a federal case about (shots, passports, fuss). Canada. Let us give you a sample weekend.

An easy day's drive from upstate New York, for instance, is the north shore of Lake Ontario.

That's where Toronto is: big city sightseeing, shopping and nightlife.

That's where Gananoque is: a charming resort area and "Gateway to the Thousand Islands," with boats leaving every hour.

That's where Old Fort Henry is: the precision-trained Guard are still executing the drills and artillery salutes of the original British garrison.

We have hundreds of weekends for you.

There's the weekend that takes you cruising from Tacoma or Seattle up through British Columbia's beautiful Gulf Islands.

There's the weekend that takes you from your eastern seaboard to ours... New Brunswick or Nova Scotia or Prince Edward Island or (with an extra day) Newfoundland.

Each province is a different kind of weekend.

Why don't you visit us for a couple of days?

In 2 days we'll do our best to make you a lifetime fan.



The Signal Hill Tattoo Guard (above) re-enacts history in ancient regimental uniforms. Signal Hill, Newfoundland, is also where Guglielmo Marconi received the world's first trans-Atlantic wireless message. For more facts about Canada, just fill out this coupon.

Canadian Government Travel Bureau, Ottawa, Canada.

Please send the Invitation to Canada package to:

Mr. / Mrs. / Miss __________

Address __________ Apt. ____

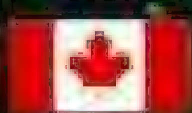
City __________

State ________ Zip Code ______









Canada

HELP WANTED

Must work 16 to 20 hours per day; doing monotonous, repetitious tasks; in areas subject to sub-zero cold, extreme heat, stench, and various hazardous gasses. No lunch, vacations, or time off. Errors will not be tolerated.

Unimation, Inc., Danbury, Conn., answered this ad with their industrial robot, the Unimate. It can be programmed to perform a variety of dull, dangerous, sub-human jobs. And, all with amazing accuracy. For example, it can position an object within 0.050 of an inch time after time, "remember" up to 180 sequential operations; recycle, stop, start, and correct itself, automatically. All in a day's work.

It was nine years back that Condec Corporation decided that it was good business to invest their time and money in the potentials of the Unimate. And, now, it's paying off. They also thought it was good business to entrust their company's insurance to Employers Insurance of Wausau. Simply because, when it comes to insurance, we know business insurance like nobody else in the business.

Employers Insurance of Wausau.



This is Unimate, product of Unimation, Inc., owned by Pullman, Inc. and Condec Corp.

Wausau Story



FOR A
VACATION
THAT IS REALLY
DIFFERENT



The dome of the Basilica of Marie-Reine-du-Monde in Montréal provides contrast to towering Place Ville-Marie.



The lock at Chambly, on the Richelieu River, is the gateway to Lake Champlain.



Throughout French Canada, dining is a fascinating adventure.



Québec's vast system of modern highways makes driving anywhere in the province easy and comfortable.



Modern resort areas are abundant throughout the Laurentian Mountains and the Eastern Townships.



Minutes from modern cities, handicrafts thrive and a more leisurely world still exists.

There's a whole world of contrast only a few hours drive away . . . in *la belle province de Québec*! Montréal is a city of two moods and two cultures . . . old-world atmosphere, the warmth and friendliness of French Canada; gleaming skyscrapers and the thrusting energy of a great metropolis. Less than forty miles from Montréal, along superhighways, the rolling hills of the Laurentian Mountains offer cool lakes and modern resort areas. Also close by are the Eastern Townships, the Richelieu River valley, rich in historic landmarks and lore. Come to Québec . . . to a holiday with a difference . . . to a welcome *à la française*.

COME TO
la belle province de
QUÉBEC
hospitalité spoken here

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Mr. ☐ Mrs. ☐ Miss ☐ ____________________
(PLEASE PRINT)

ADDRESS ____________________

CITY __________ STATE __________ ZIP __________

There's nothing plain about John Smith's Bay.

(Even the beach is pink.)

There's nothing plain about the other 79 Bermuda beaches either.
You could spend two and a half months here going to a different beach every day and find something different at every one. If you look closely, you'll see caves where pirates may have once hid their treasure. At Whale Bay, you can cast for bonefish in the shadow of a 100 year old fort. Many Bermuda beaches are considered crowded if there are more than twenty people – and the coral reefs break up the waves making the surf gentle enough for a three year old. Get some pink sand between your toes. See your travel agent. Or write Bermuda, 610 Fifth Avenue, New York 10020. 6 North Michigan Avenue, Chicago 60602.

There is only one Bermuda.



Fish used to be scared when we

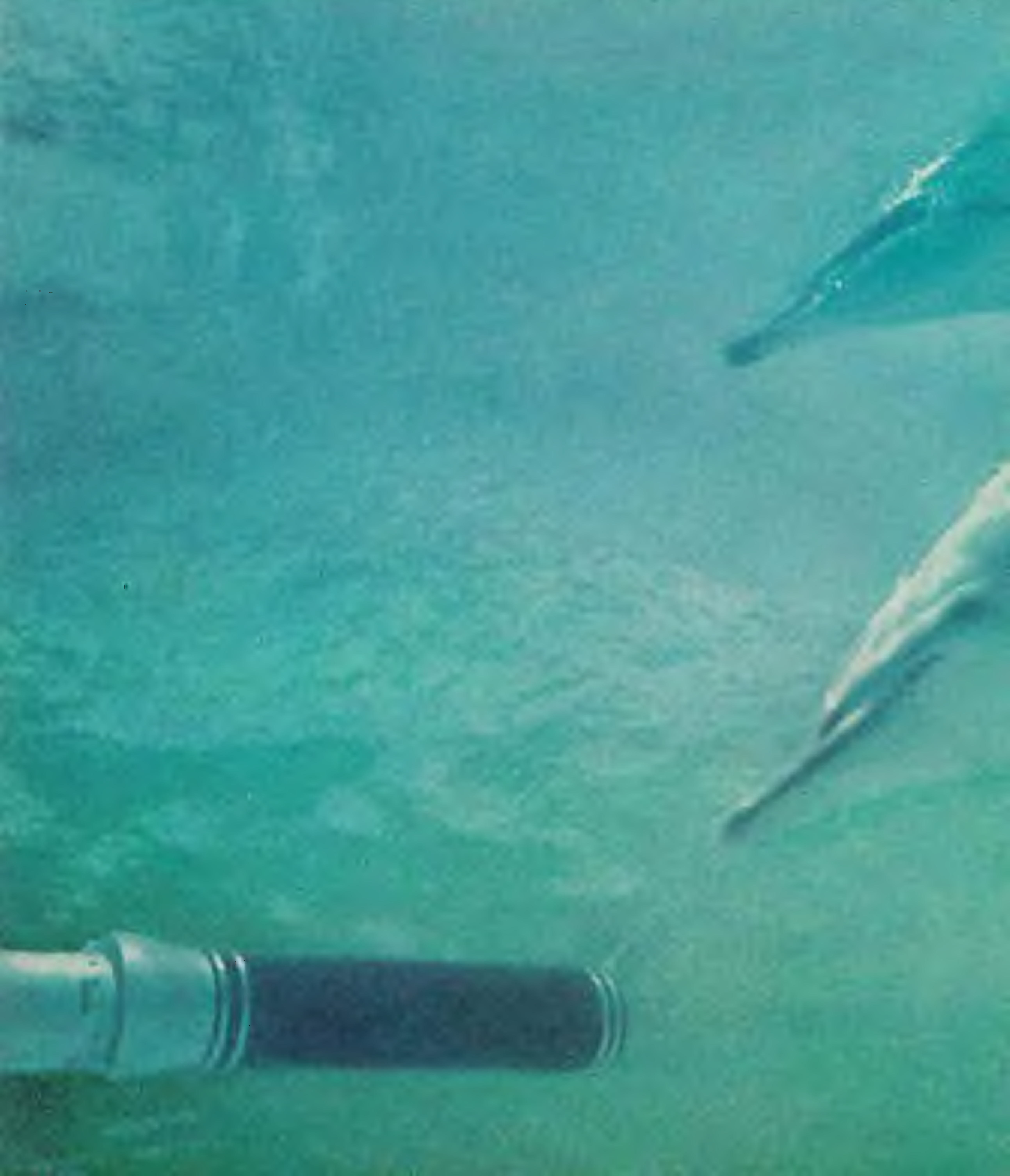
Not long ago, the oil industry usually looked for offshore oil with dynamite. They exploded it underwater and recorded the telltale echoes on a seismograph.

When carefully done, this did little or no harm to aquatic life. But fish were sometimes scared and fled to quieter waters. Fishermen frowned. They had to go farther to fish.

Now, the Esso Production Research Company (a Jersey affiliate) has invented a substitute for dynamite. We have nicknamed it the popper and you can see one at the bottom of our picture. It doesn't go bang like dynamite. It simply goes pop.

The device is beautifully simple. A mixture of propane and oxygen is ignited by a spark plug inside a rubber sleeve. The pop inflates the sleeve like an instant balloon.

This sudden expansion is fast enough to give a seismic echo, but not fast enough to



looked for oil. Now they seem interested.

scare away fish, porpoises or anything else.

What's more, it has a snorkel. This allows burned gases to escape to the surface. So the water stays clean.

But fishermen aren't the only people to cheer.

Dynamite is often tricky stuff to handle. The popper is completely safe. Exploration crews have one less danger to contend with.

And dynamite is also quite expensive. Fifteen dollars a shot. The popper costs a penny a pop and gives a better seismic picture in the bargain. At the rate the oil industry is exploring, it could literally save millions.

Good news for people. Great news for fish. Quite an invention.

Standard Oil Company (New Jersey)



The great exception:

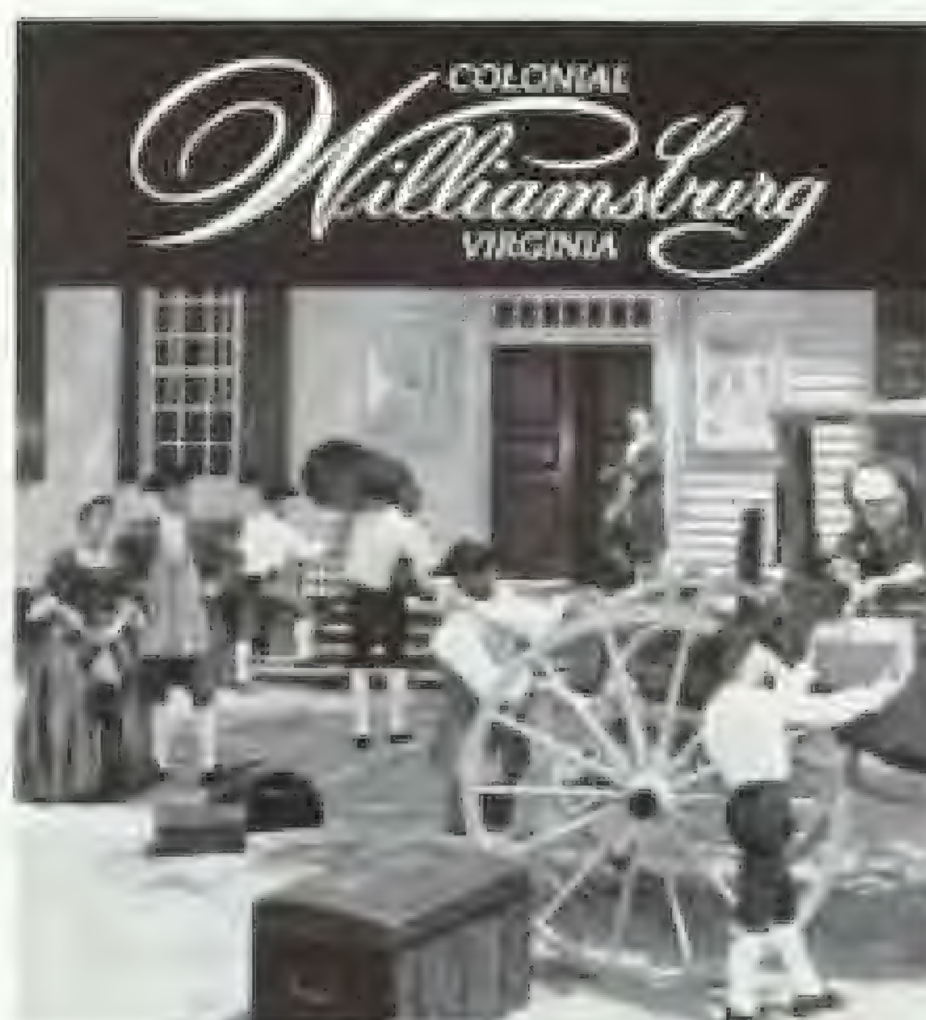
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Of all the scheduled airlines flying the Atlantic, Icelandic is the great exception. You save $161 flying Icelandic to Luxembourg in the heart of Europe. Fly with us during our 25th Anniversary year. Daily flights from New York to Iceland • Luxembourg • England • Scotland • Norway • Sweden Denmark. See your travel agent, write for folder NG.

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Plan ahead for a vacation in the past. Let us send you this beautifully illustrated booklet on what to see and enjoy in historic Williamsburg. The Governor's Palace by candlelight. Old colonial homes which have survived all change of fashion. Bustling taverns and quiet gardens. And little craft shops along the way. Williamsburg is an experience you'll never forget; not in 200 years. Write Mr. F. C. Wright, Box C, Williamsburg, Virginia 23185.

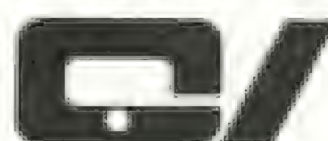
foreign intelligence



The British are famous for it, and the latest word to leak is that a revolution is underway.

A revolution in the concept of vacation traveling, called Sprite. It comes in three sizes: light but roomy, light but roomier, and light but roomiest.

The most intelligent aspect about the Sprite concept is its inherent appeal to owners of small or intermediate-sized foreign or American cars. It is an appeal based on comfort matched to the size and weight of such automobiles.



Thanks to its "stressed design" Sprite is strong and amazingly light. Hitch weight is one-quarter or less than comparable American trailers (100 lbs. is tops). Result: No expensive hitch installation. Because of independent suspension and shocks, and a low center of gravity, it holds the road with maximum safety. Driver fatigue is nonexistent, and its powerful brakes are far superior to brakes on American trailers of comparable size.

Profit from this latest leak in British intelligence. Drop us a line and our courier (the U. S. mails) will rush the name of your nearest Sprite dealer. Contact him to enjoy the surprising relaxation of a test tow. Make contact in the clear since, after all, the new British Sprite caravans are already the worst-kept secret in history.



Caravans International Imports, Inc.
Dundalk Marine Terminal, 2700 Broening Highway
Baltimore, Maryland 21222

Please send me the new full-color Sprite Brochure, together with the name of my nearest American or Canadian dealer.

Name ____________________
Street ____________________
City ____________ State ____________ Zip ____________

CI—world's largest travel trailer manufacturer Dept. NG

Sprite caravans—the happy wanderers





Stop.
Back up.
Speed forward—without clutching or shifting.
One lever Hydra Speed Drive does it all.



Steer with ease. Get in close to trees and shrubs with 34" mower.

Discover LAWNMOTORING on a Hydra Speed MF 7. Zip through lawn work at an acre an hour.

Haul, scrape, dump, spray, fertilize . . . The MF 7 makes all these jobs easier.

Go LAWNMOTORING all year. Clear leaves in the fall, snow in winter.

Massey-Ferguson introduces a great new outdoor sport

We'll help you find your nearest MF Dealer. Call any time, any day, toll free. (800) 243-1890. (In Conn., 325-2244 collect.)



The new MF 7 Lawn Tractor with Hydra Speed Drive. One lever controls forward and reverse speeds. No clutching, no shifting. Just fast, work saving performance. Now LAWNMOTORING in the 7 hp class is more fun than ever.

Massey-Ferguson also makes these great outdoor sports: The Standard MF 7 hp (at under $560*, including 34" mower), the Variable Speed MF 10 hp, and the Hydra Speed MF 12 hp. Turn the job of lawn mowing into the sport of LAWNMOTORING. See your MF Dealer for a test drive today.



Massey-Ferguson Inc., Des Moines, Iowa
World's Largest Tractor Manufacturer

*Manufacturer's suggested retail price is [illegible] (34" mower included), F.O.B. Algona, Wis. Massey-Ferguson reserves the right to change prices or specifications without notice.





Impala Custom Coupe

If elegance is understatement, you're looking at the understatement of the year.

Impala Custom Coupe.

Even sounds exclusive, doesn't it? Like something outrageously expensive, made for the "I-always-go-first-class" individuals.

To the first-class part: yes. But outrageously expensive? Hardly. Chevrolet builds it.

Now look again. At what makes the Custom Coupe elegant. At the distinctive roof line, so like a limousine. At its full door-glass styling. At its massive grille.

But Impala's good taste also comes from what we left off: the rampant slashes of chrome some cars tack on to justify their price. (We've got a name for cars that claim they're in the same class. Social climbers.)

Impala Custom Coupe is just what it sounds like. And, certainly, the people who buy it have money to spend. On other things.



Putting you first, keeps us first.

This beautiful magazine is getting you nowhere.

Take this page, for instance. It's enough to make you think you've really seen the sun come up in Rio. Except you haven't left home since you can't remember when. And if that's enough to make you cry, dry your eyes. We can show you more islands and countries and continents than you've ever dreamed. Just call a Pan Am® Travel Agent. He has all the bargains in the world. (Our 'round the world Jet Economy fare, for instance, is about $1300.) And we can have you on your way in 24 hours or less. From Nowhere to Somewhere. **Pan Am makes the going great.**



The world's most experienced airline.

Used to be, to get your kids in movies you had to spend a lot of money.



Kodak has changed all that.

Now you can launch your kids' movie careers with less than $30. That's all it takes to get our new Kodak Instamatic M12 movie camera.

We even made it palm-size



The M12 is a lot of other things besides low-priced. It's palm-size, so it's easy to take where the action is. It loads instantly, so you don't miss any of the action. It's battery-driven, so you never have to wind it.

And the movies it takes are super 8, which are so much brighter and sharper than regular 8mm movies.

The M12 also comes in an outfit with batteries, wrist strap, and color film, for less than $35.



Just drop in the film

We have other super 8 movie cameras at other prices. And since super 8 movies call for a super 8 projector, Kodak offers a wide choice there, too.

Why not see your Kodak dealer? So you can see your kids in movies.



Kodak Instamatic® movie cameras. From less than $30.

Prices subject to change without notice.

Kodak

How do you make a boat go faster, ride softer, and save gas doing it?





This Sportsman has the answer.

If you thought last year's 16' Sportsman was the ultimate in soft-riding performance, you had lots of company.

But that wasn't good enough for our designers. They proved again what some competitors found out the hard way. That a little change in shape here and there can make a big difference in performance — for better, or worse!

From the drawing board, the computer, and numerous test hulls we came up with a new shape. A deeper hull, with a foot more freeboard forward. A softer-riding hull that rides higher on a cushion of spray and trapped air bubbles. And goes 4 miles an hour faster — with fuel savings resulting from increased speed and efficiency.

If you know much about boats, you'd expect an Evinrude Gull Wing hull to outperform conventional boats several feet longer. And since it doesn't have a pointed nose, there's no waste space. It's bigger inside and smaller outside.

The wide track hull is wide open from bow to stern. A folding windshield gives you easy access to the foredeck, making the Sportsman about 40% larger than conventional boats of the same length. But you can also button it up like a snug sports car with its front tonneau cover and convertible top.

Not the least of its luxury features is its full flotation, molded in as an integral, structural part of the hull. It's the toughest boat ever built, as our test drivers prove every day.

You have a choice of seating, and a choice of power — an economy 120 hp inline-4, or a sizzling 155 hp V-6.

It's a lot of boat for its size. And a lot of boat for the money.

CATALOG FREE. Write Evinrude Motors, 4054 N. 27th St., Milwaukee, Wis. 53216

EVINRUDE *first in outboards*

Div. of Outboard Marine Corporation

The Electronic Timex sells for less than $100. $50 less.

Once again Timex has produced a fine precision watch to sell at a price considerably below what you'd expect.

This time the watch is *electronic*.

The Electronic Timex costs about half of what you'd have to pay for the higher-priced electronic watches.

And does the job of timekeeping faithfully, accurately, dependably.

It is a watch you never have to wind because it is powered by a tiny replaceable energy cell.

Its transistorized circuit provides 99.99% electronic accuracy.*

It has an automatic calendar, a convenient feature not available in any other electronic in its price range.

And you don't have to coddle it because it's water-resistant and dust-resistant.

(Tests prove that the Electronic Timex is sturdier, more rugged, than electronic watches selling for over $100.)

In fact, you don't do much with the Electronic Timex except buy it.

And enjoy it.

The Electronic Timex.
It never needs winding.

TIMEX

14

Electronic

Model illustrated: 99041 ($50)

*Regulation may be necessary to achieve this accuracy



Less than
240 calories.
99% fat-free.
100% delicious.
A good breakfast
is an essential part
of any weight control program.
Scale down and get back into things,
with the Kellogg's® Special K® Breakfast.
Kellogg's
Special
K
High Protein
THE SPECIAL K
BREAKFAST
4 ounces orange or
tomato juice
1½ cups (1 ounce)
Special K with 1
teaspoon sugar and
4 ounces skim milk
Black coffee or tea
Less than 240
calories
©1969 by Kellogg Company

What's new in dishwasher fashion? KitchenAid portables in new Golden Harvest.

You always get a lot in a KitchenAid dishwasher.

Like amazing dependability, virtually service-free operation, outstanding performance and long life.

And now, you also get the newest appliance color, golden harvest, in two handy, portable models.

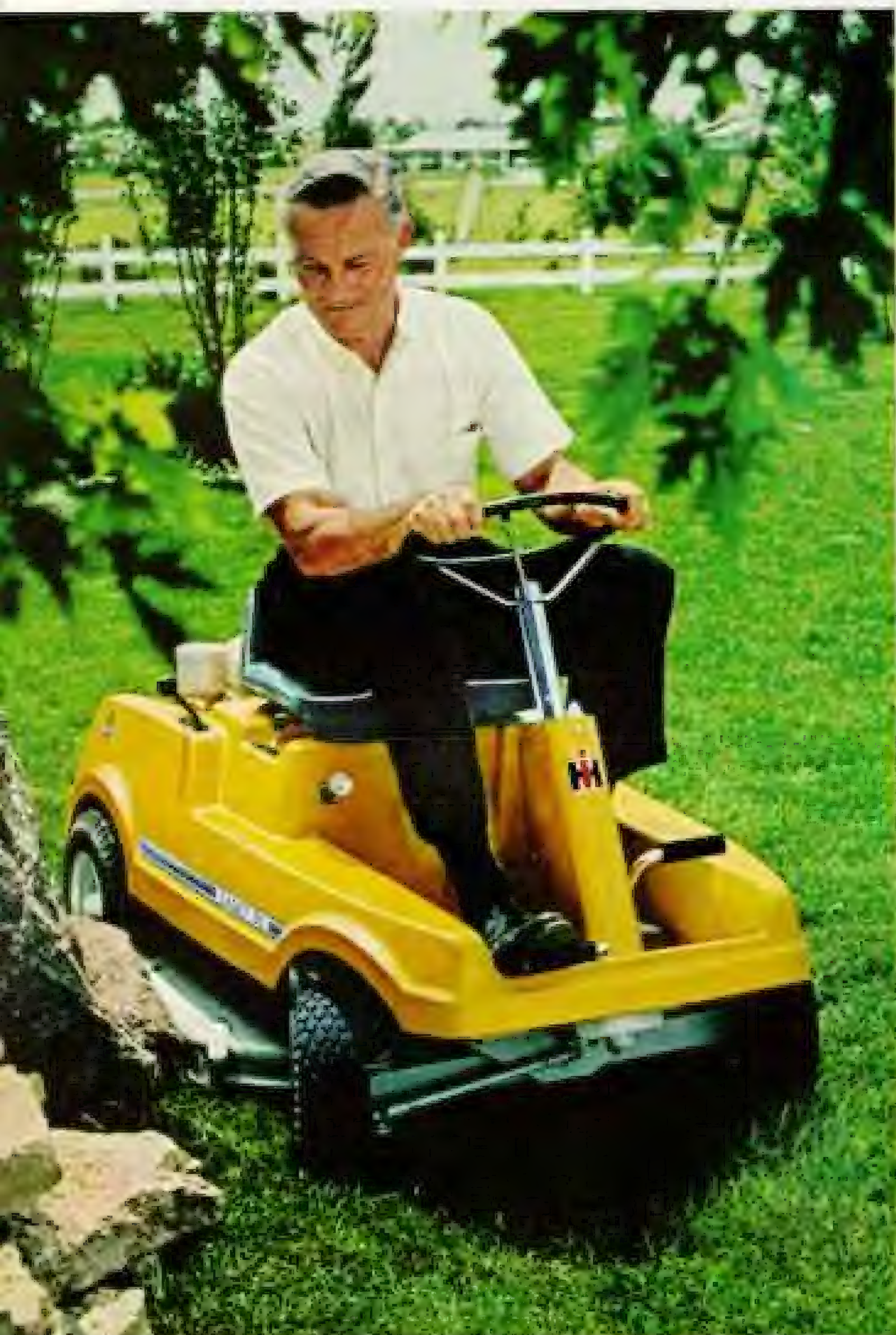
A top-loading portable that's ready to use the minute you wheel it in your kitchen. No installation necessary.

Or a front-loading convertible. You can use it as a portable now. Any time you want, you can have it built in. Easily. And there's no conversion kit to buy.

So be sure to see the new golden harvest portables at your KitchenAid dealer. (You can find him in the Yellow Pages.) Or write KitchenAid Dishwashers, Dept. 9DNG-5, The Hobart Mfg. Company, Troy, Ohio 45373.



International Cadet 60–the only riding mower tough enough to do so many jobs



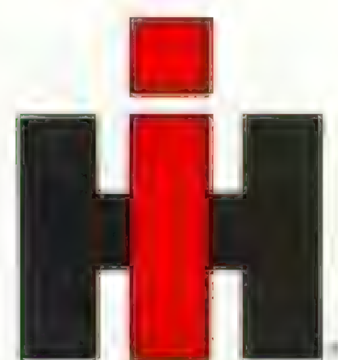
Wide 32-inch mower whips through big lawns fast.

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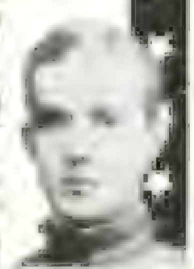
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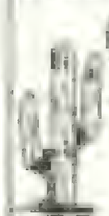
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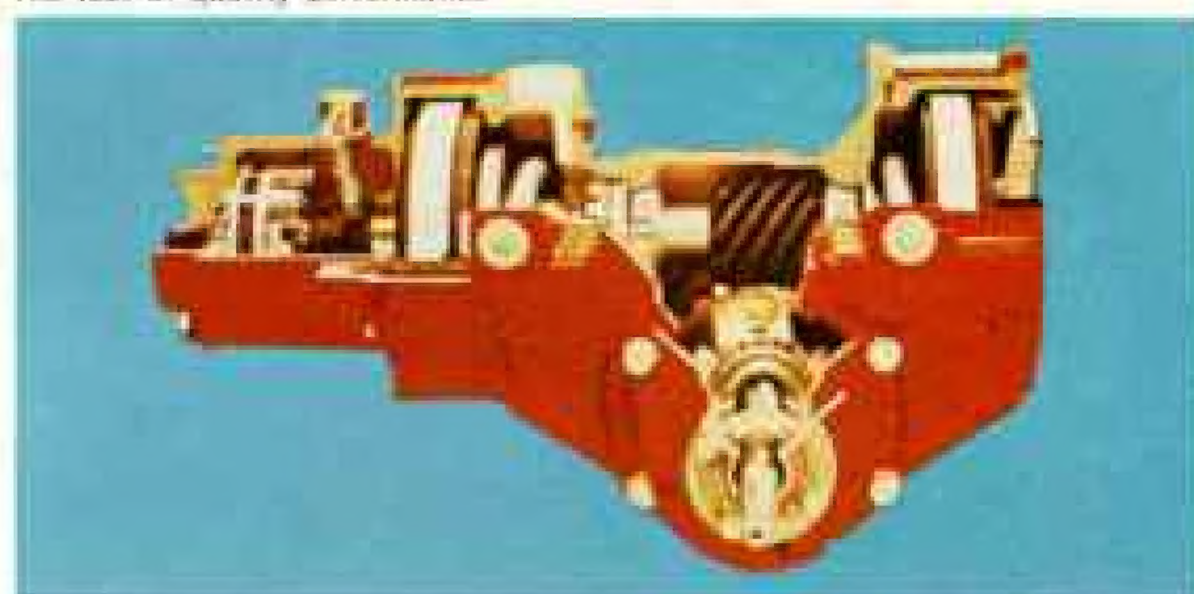
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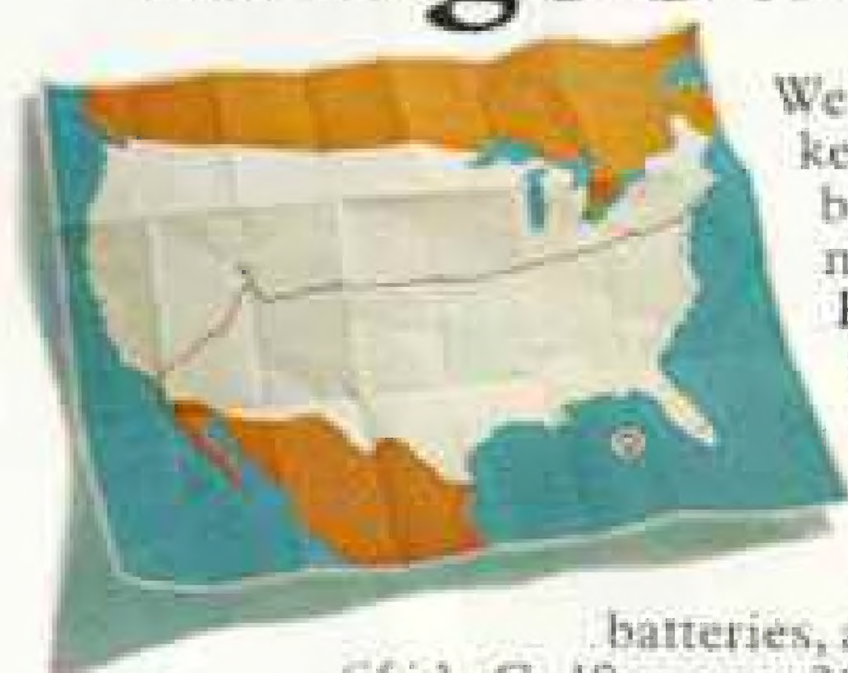
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